

**Biomechanics**  
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**Lecture - 43**  
**Grasping – Reaching– Chains**

**(Video Starts: 00:17)**

Welcome to this video on biomechanics. We have been looking at the static analysis of upper limb and lower limb. We will move on to the next topic which is dynamics. Within dynamics we restrict our attention to kinematics which is geometry of motion, which is describing how motion happens without worrying about the forces that causes or stops the motion. So, although we can study kinematics of different segments of the body, we restrict our attention to reaching and grasping for the next few classes or the next few videos.

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In this class...

- Reaching vs Grasping vs Manipulation
- Process of Grasping
- Types of Grasps
- Kinematic Chains

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So, in this video will be looking at reaching, grasping and manipulation. What is this process of grasping? What are the types of graphs and the kinematic chains?

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The image shows a presentation slide with a white background and a dark border. The title 'Reaching vs Grasping' is at the top left. Below it, 'Reaching' is defined as 'Co-ordinated movement of hand and fingers towards the object that needs to be grasped'. To the right, 'Grasping' is defined as 'The act of actually holding an object by wrapping the fingers around the object and supporting it with the palm of the hand.' On the right side of the slide, there is a vertical strip with a green robot illustration and an NPTEL logo. In the bottom right corner, a man in a light blue shirt is visible, presumably the presenter. A red banner at the bottom left contains the word 'Biomechanics' in white.

So, we are interested in analyzing reaching and grasping as we would analyze this as a mechanical system or as a machine. Because although the human body is not entirely a rigid body we consider for the purpose of this analysis, the segments of the limbs as rigid bodies. In this case since we are talking about reaching, we consider the upper arm or the bone underlying the parameters say humerus and the forearm, the two bones that underlie the forearm which is the radius and ulna as rigid bodies.

For definition a rigid body is a body that does not deform under application of an external force. So, in other words its size or shape does not change when a force is applied. Technically all bodies you know are not rigid so with a large enough force any of these bodies will either crack or will change in shape and size but for the normal physiological forces under consideration. So, for most the ranges of forces that we will be discussing these bones and their dimensions remain intact.

So, we consider this as rigid bodies and the movement of these bones with respect to each other we analyze as rigid body kinematics. So as this movement happens, how is this movement happening? This movement is happening by contraction of muscles or something that may saw the previous videos. Muscle contracts and moves one bone relative to the other bone which is what is causing the change in the joint angle or the change in the configuration of these rigid bodies.

So, when the muscle contracts what happens is that this contraction leads to a situation in which there is an accumulation of muscle mass closer to the proximal attachment. Let us remind ourselves what this proximal attachment of the muscle is called, it is called as the origin closer to the origin the muscle belly becomes big changing the mass of the whole system. So, it is not like the mass of the system is remaining distributed or the distribution of the mass of the system remains a constant as people are making movement, this is not true.

So, there is a slight variation as this happens because when the muscle contracts, the origin of the system becomes slightly heavier. So, modeling this is a non-intuitive and relatively complicated process. We restrict our attention to rigid body modeling I mentioned this we restrict our attention to rigid body modeling; in other words, we model the bones as rigid bodies and we analyze movements between the bones.

There are different types of joints that are found when these rigid bodies interact with each other in the case of the human body. For example, when we discuss the elbow joint, we consider the elbow joint to be a hinge joint so that means that it is a joint that has one degree of freedom. This movement between the upper arm and the forearm that happens at the elbow joint happening at this hinge joint one degree of freedom is one contribution to the total reaching.

What else is contributing to the reaching? The moment that happens at the shoulder joint and then the movement that happens at the wrist joint. But before we consider the wrist joint in the picture, we consider for simplicity that there are only two joints under the discussion which is the shoulder joint and the elbow joint and we consider that the shoulder joint also makes movements in the same plane as the elbow joint, this is not actually true because the shoulder joint is a much more complicated joint but for now, we consider this.

So, this is the movement this is a system under consideration for us. So, let us get back to our original discussion of reaching and grasping. What is reaching? Reaching is this coordinated movement of hand and fingers to move towards the object that needs to be grasped and manipulated. So, I am reaching an object and I want to do something with it say this is the pen that I would like to grasp and do something with it I want to write with it for example.

So, approaching the pen for example is an example of a reaching task so this is a coordinated movement of hand and fingers. Note that there will be coordination at multiple levels as the hand is approaching there will be appropriate changes in shape of the hand and fingers according to the characteristics of the object that needs to be grasped and manipulated something that we will see in future slides.

Grasping on the other hand is the act of holding and manipulating wrapping the fingers around the object either like this or like this and there are different types of these grasps. Wrapping fingers around the object and supporting it with the palm of the hand and then performing some manipulation activities with it, so this is grasping. Whereas that act of approaching the object is called reaching.

Almost always reaching is followed by grasping and grasping is preceded by reaching, so this is always the case. However, in biomechanics when we study it turns out that there are two broad fields of study, reaching and grasping. Upper limb biomechanics there is a whole body of literature that studies reaching and then there is a whole body of literature that studies grasping. Reach to grasp type of studies in comparison are rather limited.

This is because the type of analysis that is used for reaching is very different from the type of analysis that is used for grasping reach to grasp type of study requires a very complicated model and assumption and relatively complicated analysis. So, those kind of studies are present although they are available they are rather limited in number and scope.

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So, this is reaching for example reaching further so that there is the hand and then it is reaching that ball that is reaching. Now that is grasping look at that ball being held by the fingers that is grasping just for clarity repeating it one more time.

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**Grasping vs Manipulation**

**Grasping:** A grasp is every static hand posture with which an object can be held securely with one hand, irrespective of the hand orientation.

**Manipulation:** Operating a grasped object in a skillful manner to change the object orientation for different tasks.

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Now when I say grasping does it also include manipulation because sometimes, I say grasping and then manipulation, grasping and manipulation are these two things the same the answer is no, because a grasp is every static hand posture that can be held securely with one hand regardless of the orientation. So, I am holding that is grasp this is a grasp this is a grasp, these are grasps various types of grasps.

Manipulation involves an operation involves change of an orientation or a slight translation some kind of a movement of the grasped object. So, operating a grasp the object in a presumably in a skilled manner in a skillful manner so that the object orientation and its position is slightly altered to perform what is considered purposive or meaningful moment. So, anything we do must have a meaning it turns out that there are different kinds of movements that humans make most moments.

We would like to think that the most of the moments that we make are purposive moments or meaningful moments there is a reason why you do this there is a meaning for it there is a purpose behind this. So, most purposive moments are we like to think that these purposive moments are voluntarily controlled are those that are skillfully learned or learned and then applied using some control mechanism from the central nervous system. So, that is the idea.

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For example, you have this object and that is being grasped like this for example this is grasping, so there is a glass that is being grasped like that right and then you have this object that is being manipulated in hand manipulation like I am having the pen and then I am writing with it. The pen does not leave the hand but there is some movement that is performed that I am performing, to produce some desired purposive outcome.

For example, like this right this is manipulation of a tool there is a tool that they are rotating, remember this is actually you know you are holding this object with several fingers wrapped around the object and then you are using these two fingers to move a particular movable part of this tool to operate to perform a purposive action. Let us go back and visualize this one more time, so this is the handheld tool which is being manipulated by this person this is what is being done.

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**Phases in grasping**

- ❖ **Pre-grasp phase:** First phase of the grasping task which precedes the actual act of grasping.
- ❖ **Grasp phase:** The fingers wrap around the object. The type of grasp employed depends on the object size, shape as well as the intended use.
- ❖ **Manipulation phase:** The manipulation phase is characterized by hand motions resulting in the purposeful movement of the object relative to the environment.

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So, this is manipulation, so you are holding the object and changing its mechanical characteristics in terms of its orientation there may even be slight translation and so on so forth. So, grasping itself can be classified into three distinct phases not including if you do not include a manipulation then two distinct phases one is the pre-grasp phase this is the phase in which the object has not yet been touched by the fingers.

So, this is the first phase of the grasping task which precedes the actual act of grasping which precedes the actual act of touching the object. Then grasping itself this is when the fingers wrap around the object, remember depending on the type of object the shape of the object, the texture of the object, the size of the object, the grasp type might vary but not just that it turns out that depending on what you plan to do with the object the type of grasp variation.

For example, if there is a pen that I am picking up from the table that I am planning to use for writing I would pick it up in such a way that my thumb and index finger are likely to hold it so that I will write with it like this. Suppose the pen is here I will pick it up like this so that I can write like this but suppose the same pen is here I would like to pass this pen to somebody to write, someone is asking can you pick up that pen for me and then I am taking, in that case the grasp detail will vary the way a grasp it will be different.

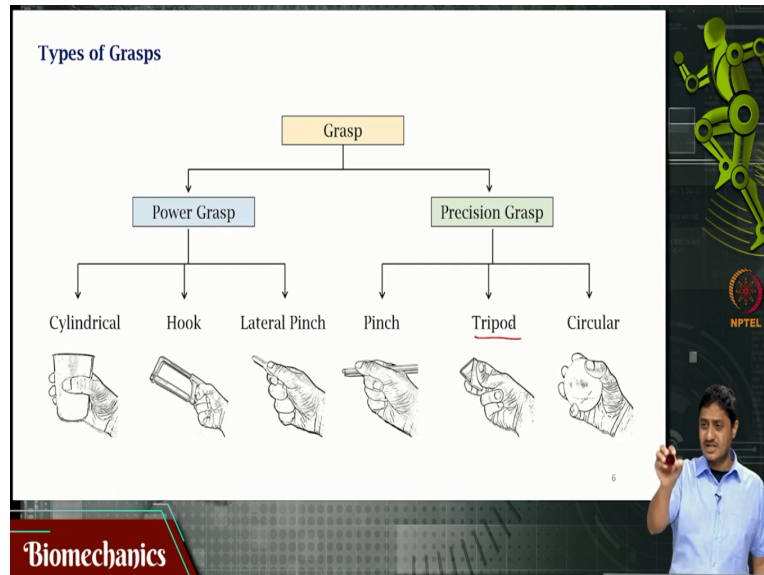
Now I am not going to write with this pen it is the same pen, it is the same hand that is grasping the pen, the purpose is different so mechanics can be a window to identify the purpose of movement. So, I will grasp such that I will give it to someone in the second case, in the first case I will grasp such that I will write with it so there is a detail that varies under dimension purposeful moment of the object related to the environment.

So, what is the purpose of this depending on that the manipulation, depending on that the grasp planning will change, depending on the grasp phase will change, depending on the pre-grasp field change. So, that means almost all cases the purpose of the movement is the king is what defines how the previous phases of the movement are going to be, that also means that by analyzing specific stages of the grasp I can understand, what is the purpose?

What could be the purpose? What is the intention is something that I can understand by analyzing the mechanics of the movement itself, something to keep in mind. You could do this experiment on yourself you could take a pen while you are writing you can take a video camera. And you know videography yourself grasping a pen so that you will write and then take the same pen to pass it on to somebody.

You will realize the way you hold the pin with the fingers is completely different because the purpose is different something to note and keep in mind, this is always the case. So, the purpose defines the end justifies the means so the purpose defines the method that is used to you know hold grasp and plan the pre-grasp.

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So, what are the types of grasps that are there? Actually, there are too many types of grasps, here we just defined this into these five six broad categories. One is a cylindrical grasp like I have this bottle and I am grasping like this so that my this is actually not a cylinder per say more like a cone, I am grasping assume that this is a cylinder and you know I am grasping my fingers around this bottle like this cylindrical grasp or then let us say that you are holding a hook you are holding a tool let us say in this case a saw like that and then you are holding.

This is slightly different from the cylindrical grasp because my fingers are wrapped around such that the fingertips are ending on the palm itself, for example this is not how it happens in the case of the cylindrical grasp because if you see here my fingertips are not touching the palm because the object is we can assume this object to be a rigid body it is not a rigid but you can already see the deformation but we can assume this to be a rigid body because of this rigid body these fingers are not able to touch the fingers.



In the case of the hook grasp you see that I am holding it like this and the fingertips are touching the palm. Then you have the keys I am having a key that I am planning to you know manipulate to open the lock, by the way trivial as it might sound this is actually a very complicated task in mechanics because you will have to produce force in two different directions, a couple to rotate and that will have to be produced over a relatively very small area.

So, on the two edges of the key which you will have to enter through a relatively small narrow hole, very complicated and trivial as it mentioned we take this task for granted all the time yet there are groups of individuals who are not healthy who find it very difficult to perform this task, this keyhole manipulation very complicated task, this pinch is sideways your grasping this key on two sides of this object also called lateral pinch, this is one type of pinch.

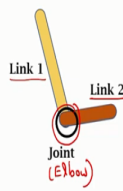
Then you have precision grasp which you know is classified into different types in this case this is a pinch grasp pinch grip with two fingers pinch grip or I am grasping with three fingers in this case. Note the way these fingers are located configured depends on the purpose with which you want to manipulate in that object in future but in general you observe that there are three such that they form three legs of a tripod also called as a tripod grasp.

Then you can hold a circular object it like this in this my fingers it appears as this is a small circular object that is why these fingers are almost touching each other but then you see that I am still grasping this object around this circle the circular grasp.

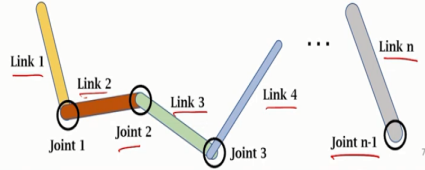
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**Kinematic Chains**

**Kinematic Pair:** Consists of 2 rigid bodies connected by a joint between them.



**Kinematic Chain:** An assembly of rigid bodies/links connected by joints in order to perform desired motion under a set of constraints.



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While discussing arm reach, we are interested in analyzing the upper limb system as a kinematic chain. So, you can for example consider the upper arm to be one link which is a rigid body and the forearm or the lower arm to be another link another rigid body. They both are connected by a joint, in this case this is the elbow joint. So, these two rigid bodies connected with exactly one joint between them is called as a kinematic pair, this is two rigid bodies connected by a joint between them.

If I have an assembly of rigid bodies connected by joints such that you know they have to perform some task under some set of constraints number of such links that is one link, two link, three link you know three link four links and so on and there are several joints in this case there are  $n$  links and  $n - 1$  joints it is called as a kinematic chain. What is the difference between a kinematic pair and a kinematic chain?

A kinematic pair is a kinematic chain with exactly two rigid bodies if you have only two rigid bodies then that is a kinematic pair. But if you have more than that it is called as a kinematic chain. So kinematic pair is a particular case of the more general kinematic chain.

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**Summary**

- Reaching vs Grasping vs Manipulation
- Process of Grasping
- Types of Grasps
- Kinematic Chains

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So, in this video we saw what is reaching, what is grasping, what is manipulation, what are the types of grasps, what is the process, what are the various steps involved in grasping, what are the types of grasps and what is a kinematic pair and what is a kinematic chain and how purposive movement or purpose of the grasp to a large extent contributes to the way in which you grasp and hold the object. With this we come to the end of this video, thank you very much for your attention.