Basics of Mechanical Engineering-1

Prof. J. Ramkumar

Dr. Amandeep Singh

Department of Mechanical Engineering

Indian Institute of Technology, Kanpur

Week 08

Lecture 31

Linkages and Mechanisms

Welcome to the next lecture on Linkages and Mechanisms. This is a very important topic when we discuss through this entire course. Machines are supposed to do a particular task or multiple tasks. In a machine, you will have a structure, then you will have a mechanism. What is Mechanism?

Mechanism is the heart of a machine. And when you talk about mechanism, there is a component called Linkage or Links. So that is what is the link between Linkages, Mechanism and Machines. When we try to look into any machines, you will have structure, then you will have mechanisms; the structure when you talk in civil engineering terms can be the frame on which the building is constructed. When you talk about a bus, a frame on which the bus is constructed, for example, you will have a frame, and then on the frame you put all the stainless steel material and cover the bus.

So that is the base structure. The skeleton is called as a frame. And when you raise high-rise buildings, again, it is the structure. So you can have structures, and then inside the structure you can have mechanisms. When you look at a cycle, the frame whatever you have like a triangle is a structure. And the chain where you have is a Mechanism.

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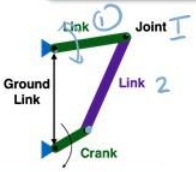
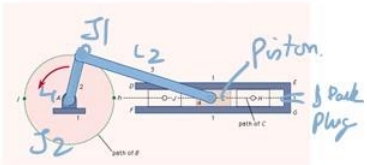
In this lecture, we will try to have an Introduction, then Introduction to Linkages, Mechanisms, Four Bar Linkages, Kinematic Pair, Kinematic Chain. And then we will try to see various mechanisms like Quick Return Mechanism, Cam and Follower Mechanism, Inversion of a Mechanism, then few real world examples and then finally we will try to have a recap.

Introduction



- **Linkages:** Linkages are fundamental components in mechanical systems that connect different parts to transfer motion and force. Linkages can be as simple as a lever or as complex as the multi-bar linkages found in robotic arms.
- **Mechanisms:** Mechanisms are assemblies of linkages that are designed to perform specific functions within a mechanical system. Common examples include crank-slider mechanisms in engines and four-bar linkages in various machinery.
- **Applications in Engineering:** Linkages and mechanisms are essential in many engineering fields. In automotive engineering, they are used in suspension systems and steering linkages.



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Linkages: Linkages are the fundamental components in mechanical systems that connects different parts to transfer motion and force.

Two components are involved. One is motion transfer, the other one is force transfer. Two important things are there. Linkages is used to transfer motion and forces. Linkages can be as simple as a lever to as complex as a multi-bar linkage used in a robotic arm.

Robotic arm is like your hand which has a movement and you will have all this hand has lot of linkages and these linkages has to be moved and when we try to carry a weight it also has a force. So if you see here, there is a crank. This crank moves like a lever. This crank is in turn attached to a link from here. Let us keep it as link 1, then joint 1, so link 2.

So a crank is attached to a link 2, then link 1 and link 2 are joined together at joint 1. So now when the crank moves like this, you will see there will be a motion which goes up and down. There will be a motion which goes up and down. So let us look into Mechanisms. Mechanisms are assemblies of linkage that are designed to perform a specific function within a mechanical system.

This is what I said. Machine, mechanism, linkage or linkage, mechanism, machine. Okay. When we talk about machine, tractor is a machine. Then we have your cycle wherein which your health cycle is a machine.

Bus is a machine. Car is a machine. A drilling machine is a machine. So these are all machines which will have a structure mechanisms. Right. So application in engineering is the linkages and mechanisms are essential in many engineering fields.

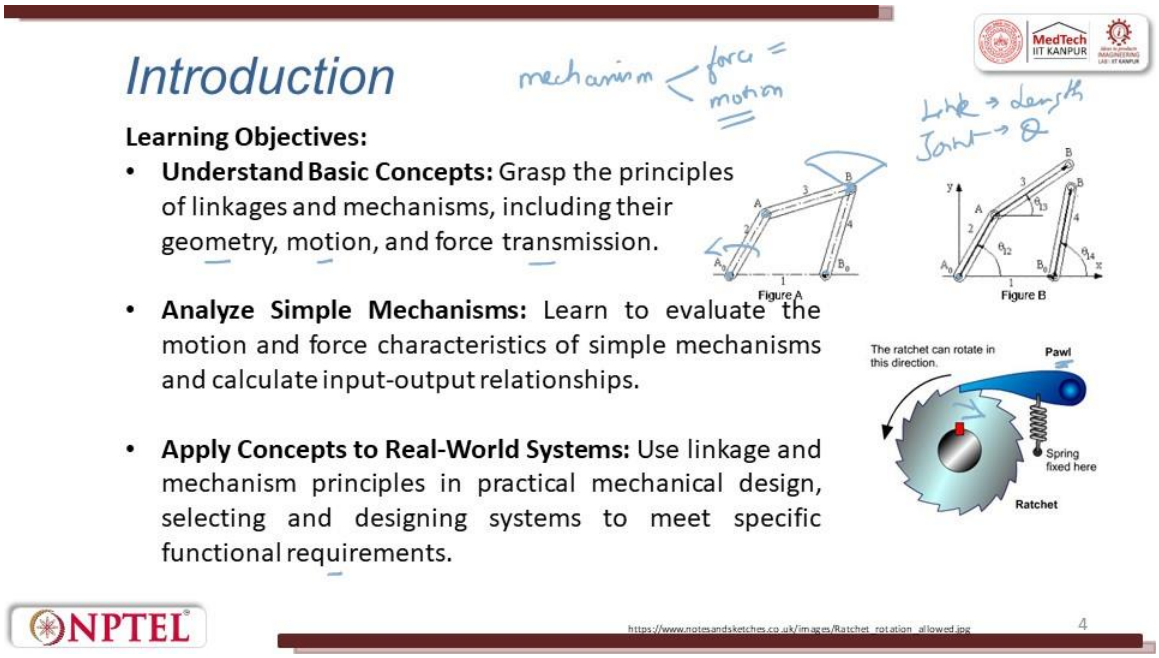
In automobile particularly they are used in suspension systems and steering linkages. All these things which you make from a Lego kit will have gears, then you will have a frame, then you will have a tool which moves up and down. All these things are called as Mechanisms which tries to move the toy.

Here in which there is no gears, but you will have linkages when you pull a leg, so you can see the bones moving and the lion or the leopard galloping, you can see that. When you look at this mechanism, whatever is there, slider crank.

So you see here, there is a link. This is a link. So you have a joint here. Joint here, J1, J2, link 1, link 2. Now this link is attached to an output, whatever it is.

So it is attached to a piston which slides inside a cylinder. If you look into it, it is a typical automobile application. You will have a spark plug here which tries to excite the air-fuel mixture. So inside which there is a combustion. This combustion tries to exert pressure.

So this pressure moves the piston up and down. When the piston moves up and down, this piston is attached to a joint and this joint will move the link back and forth. When the link moves, you can transfer it to the wheel or it can go vice versa. So, the mechanisms are very important.



In this lecture, our learning objectives will be understand the basic concept, grasp the principles of linkage and mechanism, including their geometry, motion and force transmission.

As I told you, mechanism will have two things. One is force, the other one is motion. You can have only motion, only force, you can have a combination of this. We will also analyze the simple mechanisms, learn to evaluate the motion and force characteristics of simple mechanisms and calculate input-output relationship.

So, here we apply concepts to real world systems, use linkages and mechanism principle in practical mechanical design, selecting and designing systems to meet specific functional requirement.

So, you can see the ratchet wheel mechanism is used here. This is paul. So, paul is spring loaded. So, that means to say every time when you move, there is one click. So it stops with one teeth motion.

When you try to go in the opposite direction, you can press the paul and the rat's head can rotate. See, this is a self-locking mechanism. So, if you go in the inverse direction, you can see there will be a slipping happening. That is why in bicycles, when you go in the forward direction, you will feel there will be a transformation of motion. When we go reverse direction, there will be a cluck-cluck sound.

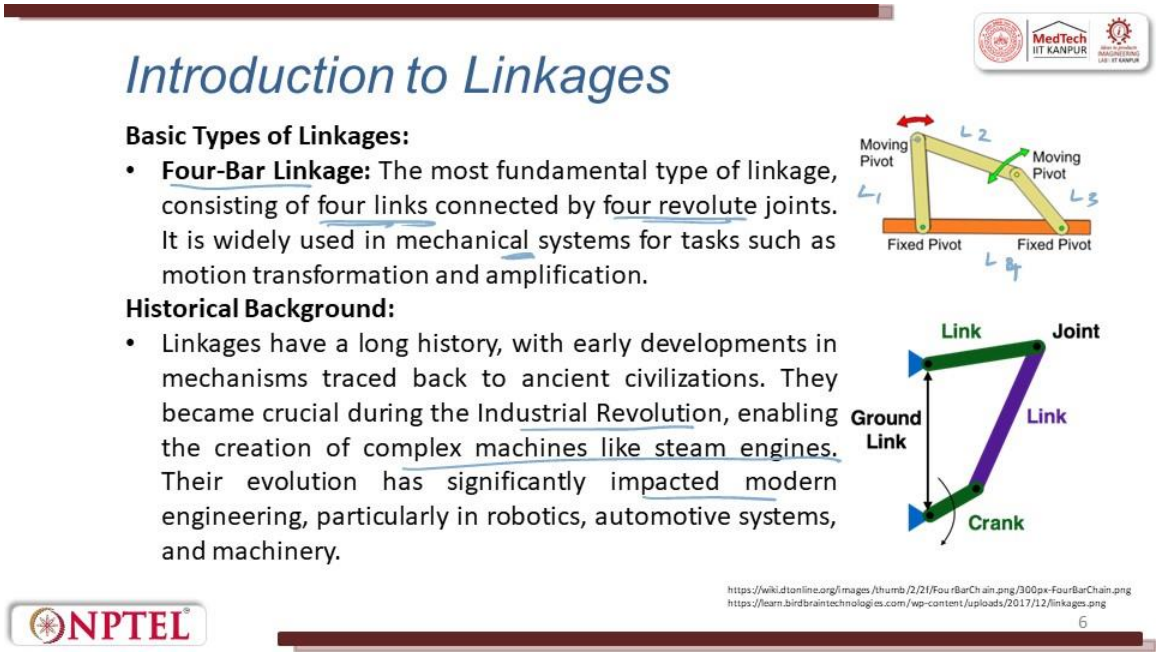
So, that is nothing but Ratchet and Paul mechanism, it is there. And linkages, if you see joints, links are there. When we try to pull one, here you can try to have some motion like a sector getting cleaned, a wiper which is getting moved. This is a closed one. This is a open one.

And again, interestingly, what you have to define in the link, you will have to define the length. And when you make a joint, then you will have to make a theta there. So, this is theta. What angle does the link move with respect to the joint? Linkages are assemblies of rigid bodies known as link.

Connected by joints to form either a closed chain or a series of closed chain. Can be one closed chain, it can be series of closed chain. They are designed to transfer motion and force within mechanical systems. So what are Links and Joints? Links are nothing but a rigid component in a linkage that moves or remains stationary relative to each other is nothing but a link.

So this is link. This is a joint and this is a joint. It can be in linear fashion. It can also be in sector/arc fashion. That means to say you make a slot or you push this, then this will move an output.

So here it is only a segment which is used. So here it is finite position. You can also have a slot to vary and have infinite the vertical movement whatever it is.



So if you look into other mechanisms like your crane crusher is also a mechanism. Your staircase climbing robo is a mechanism.

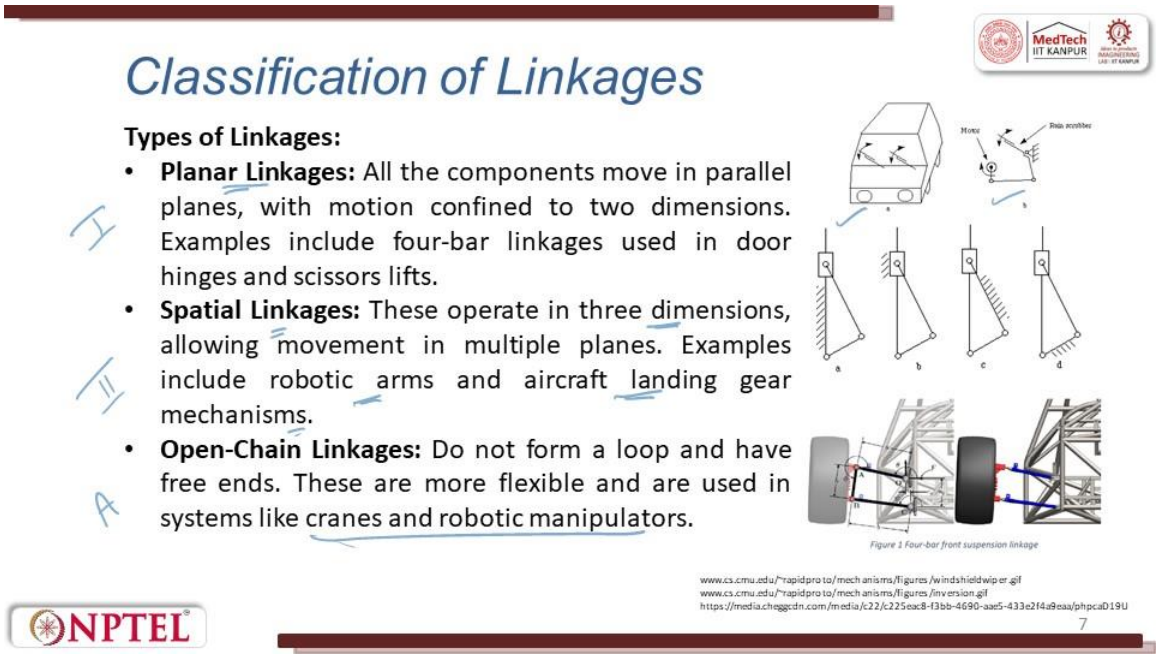
You have some mechanism inside that also decides it. And then you want to move in your health lab or in your fitness room. You would like to have a structure which goes up and down. That is also a mechanism. So you see a mechanism can be used at multiple places.

First, let us try to understand what is 4 bar linkage. So, in 4 bar linkage, you will have linkages that consist 4 links, 4 links connected to 4 revolute joints, which are widely used in mechanical systems for tasks such as motion transmission and amplification. So, link 1, 2, 3 and then ground link 4. So, you have a fixed link, then you have pivots which are attached to it, then each link you will be attached to a joint and here you move L2 and then you will try to have a motion in L2 which is connecting L3 also. Linkages have not come into existence now, they have a long history.

With early development in mechanisms traced back to ancient civilization mechanisms have been there. So, in fact, the mechanisms of throwing bombs or throwing heavy weights on the opponent during a war also has a mechanism. Spring-loaded, they put a very heavy steel ball, they hit, hammer it, and then that travels in a projectile motion to hit at the neighbors. And opening and closing of the kingdom's door, when you go to

many of the forts, you see a very massive structure door. So that will be in turn moved or reciprocated in a swinging action or in a sliding action, there also we use mechanisms.

When you visit any of the big temples, you will see heavy doors which needs at least 6-7 people to open and close. There also they have these mechanisms. So it has a long history. They became crucial during the industrial revolution. Enabling the creation of complex machines like steam engine, their evolution have significantly impacted modern engineering, particularly robotics, automobile and machinery.



So when we talk about linkages, there are types of linkages. What are the types? One, it is only Planar motion. In a plane, it moves up and down. It rotates, wipes, slides in a plane.

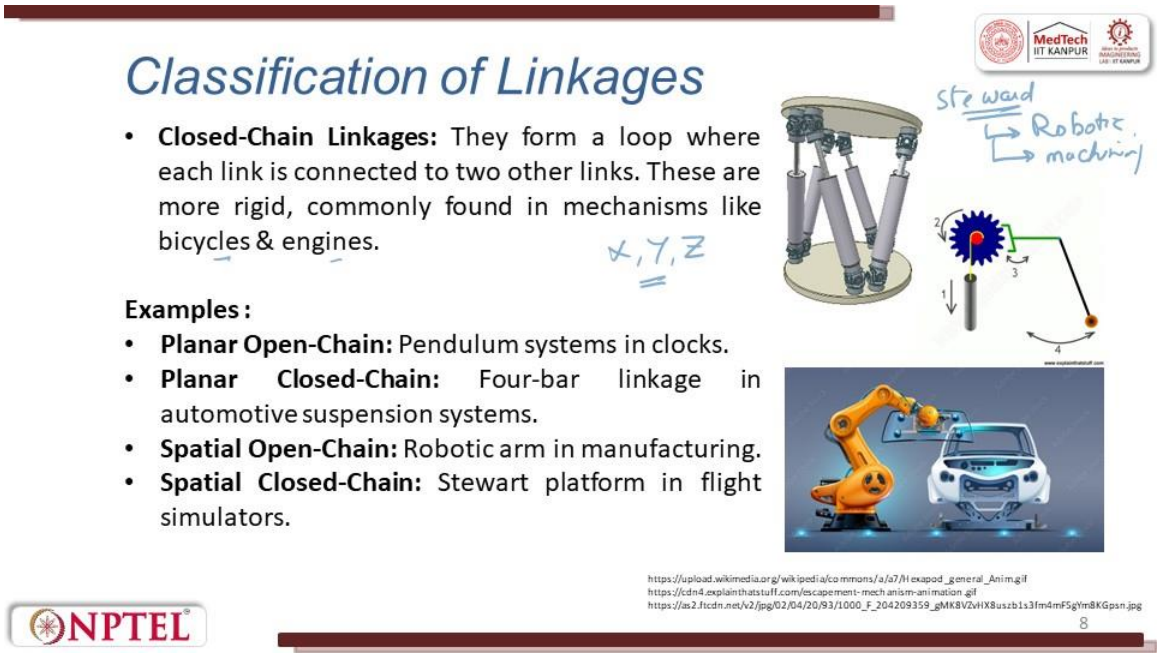
So, the other way is in a space. See, earlier I moved it in a plane, wiper of a car in a plane. Now, I am using a robotic arm to clean the floor. So, I clean it in an arc formation. In XY, I try to clean and also I move in Z direction.

So, three-dimensional. So, you can have Planar linkage, Spatial linkage. All the components which move in parallel planes with motion confined to two dimensions or planar linkages. Wiper of a car, which is used for cleaning the pan or some reciprocating motion you want in a plane. Spatial linkages are linkages which operate in three-dimensional, allowing movement in multiple planes.

Example, robotic arm, aircraft landing gear mechanism. Aircraft landing gear is also a typical mechanism. It is a mechanism which we generally discuss in length in mechanical engineering. Open-Chain linkage and Closed-Chain linkage. Open-Chain linkage, they do not form a loop and have freehands, like I move my hand, freehands.

They are more flexible and are used in systems like cranes and robotic arm. So, this is one type. This is other type. So you will have a closed one. Before we move to closed one, let us see some examples where the spatial linkages.

In car steering, we have spatial linkages. In robotic arm, we have spatial linkages. So here if you look at it, in a plane, you have a reciprocating motion. So it is in a plane, you will have a motion. So this is a planar linkage.

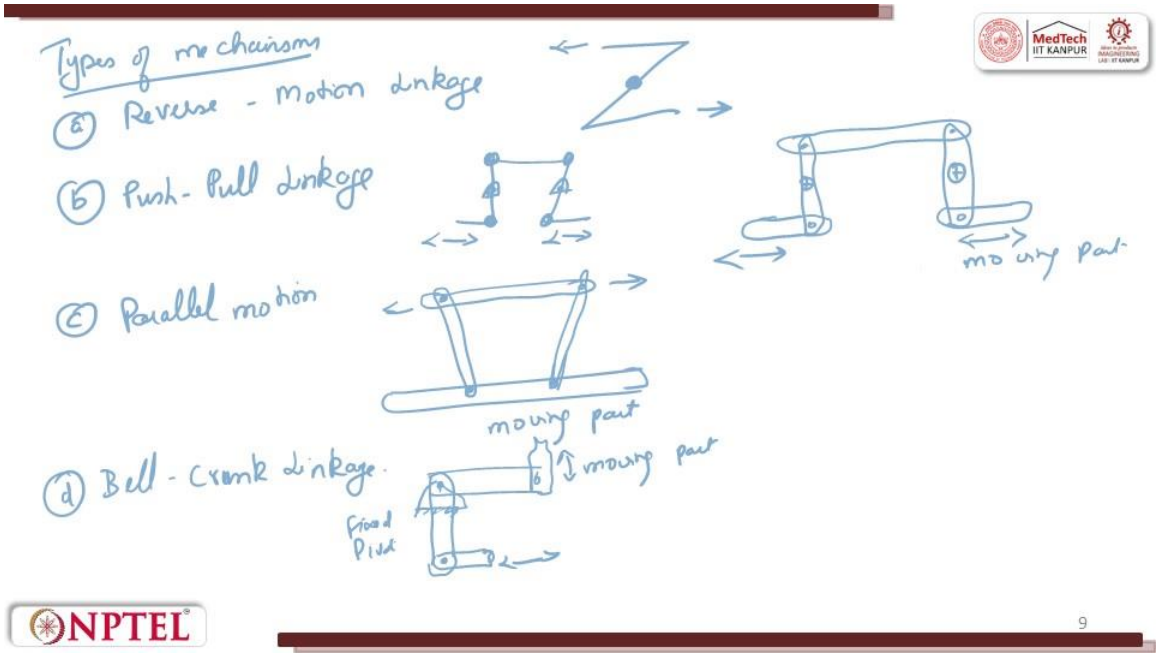


When we try to talk about Closed linkage, they form a loop where each link is connected to another link. These are more rigid, commonly used in mechanisms like bicycle and engine. So, if you look at it, this is a steward platform which is exhaustively used in robotic arm and machining. There are other applications, but in machining also it is trying to do. What is the best part of it?

So here you have a polar coordinate system to control or in Cartesian coordinate also, you see that X, Y, Z motion of the arms. Here it is controlled hydraulically or pneumatically.

So they are all independent. And they can all be precisely controlled. So the examples of planar Open-Chain is pendulum system in a clock.

Then planar Closed link is a four bar mechanism used in automobile suspension. Spatial opening-chain is in the robotic arm we have already discussed. Spatial closed is a steward platform which is used in flight simulators. Everywhere they use these examples.



So, what are the different types of mechanisms? There are many, but I am just giving you some of the examples. In fact, the scissor lift which is used in cranes when you see in construction industry, that is also a linkage mechanism is used, which is used in airports from the ground level to lift all the food items or other necessary items or to move a stretcher from a plane to a ground level, we use a scissor lift that is also a mechanism.

So, some of the types of mechanisms are one is Reverse-Motion linkage you can have. So, in Reverse-Motion linkage, you will have a pivot here and then you will move this. So, you can move this.

This is a reverse motion. These are all links and here is a joint. So, B you can try to have Push-Pull. It is left to your smartness how do you use which linkage or mechanisms. So, here if you see it will be.

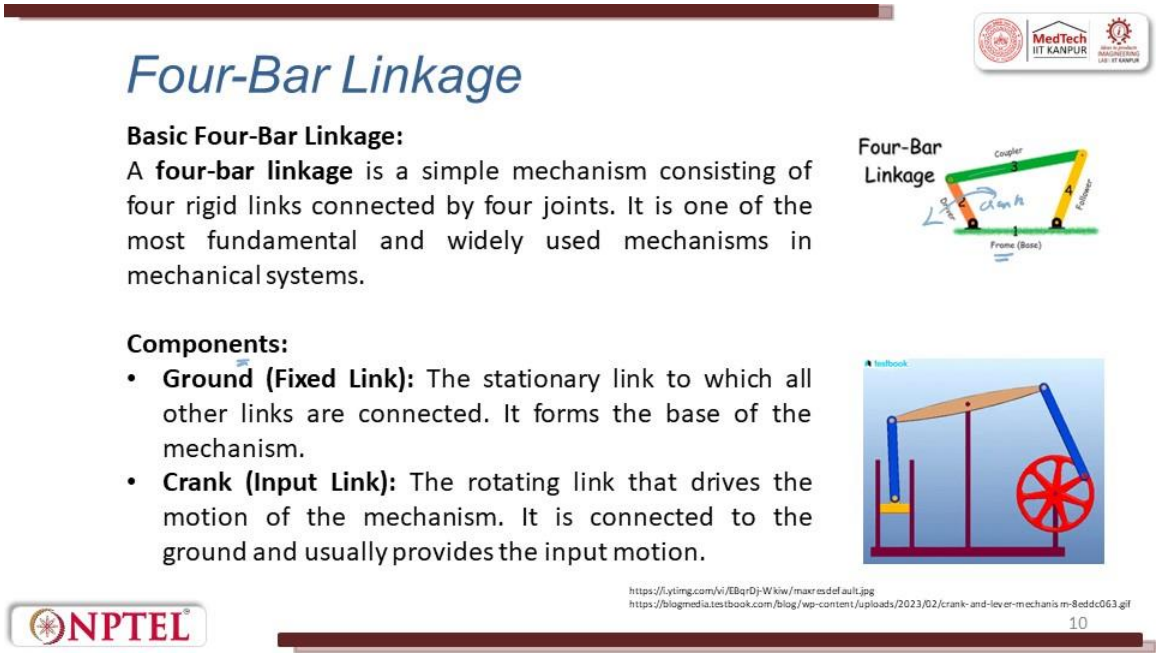
So, here is a joint, here is a joint and here this can move and again this can move. So here you will have a, you are having fixed. The third one is you can have Parallel Motion linkage. In Parallel motion linkage, let me draw the linkage itself so that you can understand. So, these are all the joints.

So, it can move this you can move this way that way you can keep moving. So, here is a moving part, ok. So, if you want to convert this also into a linkage. So, it will be something like this you will have a link you will have a link. So, here this is motion here, this is moving part.

So, this will be your moving part. In the similar way you can also have for this. The D type which I was interested to show you is Bell-Crank linkage, wherein which you will have a linkage. And then you can have a mechanism which goes like this. So, here if we try to move this.

So, this is a fixed joint. So, you will have. So, here it is a fixed pivot. And here it is the moving. This is moving.

So, these are some of the moving part. These are some of the mechanisms or linkages which I thought I will give you. And based on each of them they have examples.

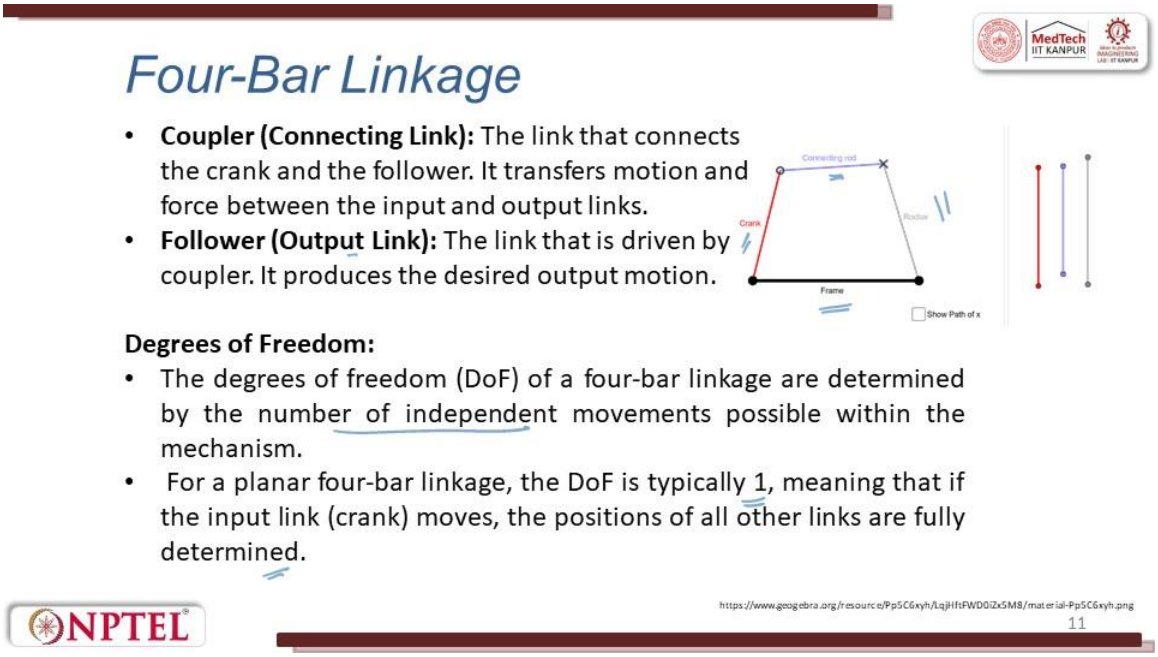


Now let us understand Four-Bar mechanism. In a Four-Bar mechanism, you will have a frame which is at the base.

Then you will have a driver which drives the entire circuit. You will have a coupler which links between these two coupler. Then you will have a follower based on this motion. You will try to see the A moving up and down. It is a simple mechanism consisting of four rigid connected by four joints.

It is one of the most fundamental and widely used mechanisms in mechanical engineering. So, the components whatever we have is a ground which is fixed. The stationary link to which all other links are connected is called as the ground or it is called as the base. Next, we have a Crank. Crank is a place where we used to give an input.

So, this is called as Crank. So, crank, the rotating link that drives the motion of the mechanism, it is connected to the ground and usually provides an input motion. For example, if you see this wheel is a crank.



Then you have a coupler which is nothing but a connecting, I have already told you, 3. So the linkage that connects the crank and the follower, where is the follower?

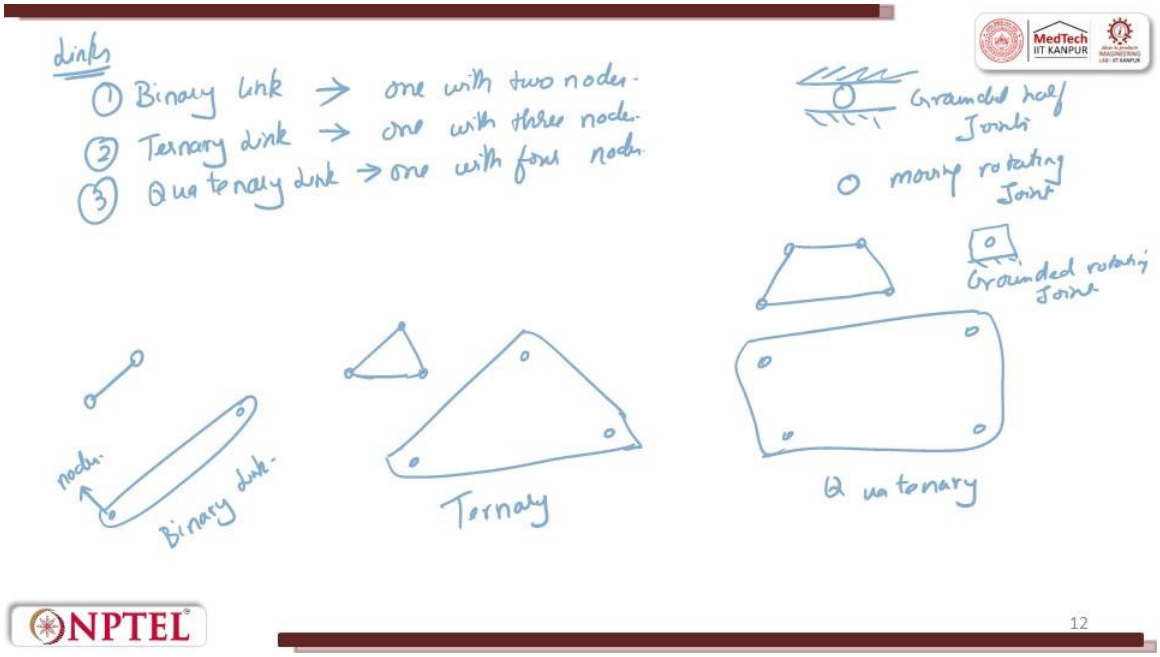
Yellow is a follower, A, or 4 is a follower. So the linkage that connects the crank and the follower, it transfers motion and force between the input and output. And the last one is

going to be the follower which is nothing but the output. What is a follower? The yellow link is a follower.

Follower is the link that is driven by coupler. It produces the desired output motion. I would like to repeat coupler. Later we will see. Coupler which is a connecting link.

Connecting link is 3. So, the link that connects the crank and the follower which transfers the motion and force between the input and output. So, this is the base is called as a Frame, this is called as a Crank, this is called as a Connecting rod and this is called as a rRocker. So, now once this is done, the next important thing is Degrees of Freedom. Degrees of Freedom of a 4 bar linkage are determined by the number of independent movements possible within the mechanism.

So how many different motions it can have independently is what is degrees of freedom. For a planar 4 bar linkage, the degree of freedom is typically 1. Meaning that if the input link moves, the position of all other links are fully determined.



In links, there are different types. One is called as a Binary link. Binary link means one with two nodes. So, I will have a link. This is a link. This is called as Binary link. And what are these?

These are called the Nodes. You can have Ternary links. Here you will have one with three nodes. It's like a triangle. This is ternary. Right.

You can have three is Quaternary link. So, what is Quaternary? One with four nodes, which are something like this. Your links need not be always binary. It can be ternary.

It can be also quaternary. And why is this links talk more is because when we talk about degrees of freedom and motion getting transferred, we always look forward for the correct possible links. So now let us try to solve a simple problem with. So binary links can be represented like this. Ternary links by a triangle.

You will have Nodes (Quantra). The other one you can also have something called as Grounded half joints. These are Grounded half joints. So, you can have many more things. So, we can have a moving Rotating joint.

So, it is grounded half joint. If you just represent it by a circle, it is called as Moving Rotating joint. Then you can have grounded half joint. You can have grounded, I said half here. You can also have grounded full joint or grounded rotating joint.

You can have this. So, these are all different joints which are there so that basically the links can add and then give a motion to it. Now, let us try to figure out Degrees of Freedom. In Degrees of Freedom, as I told you, independent motion which can happen. You can have a structure which is a superstructure or a structure with degrees of freedom.

What are superstructures? Definitely you have to give a drive to that mechanism so that the entire mechanism can move. Or it is such a rigid one where drive externally has to be given. So those mechanisms are called as superstructure mechanisms or stupor structure when you try to figure out degrees of freedom.

Four-Bar Linkage

Gruebler's Equation:

Gruebler's equation is used to calculate the degrees of freedom for planar mechanisms: $DoF = 3(n-1) - 2j_1 - j_2$

where:

- n = number of links,
- j_1 = number of single-degree-of-freedom joints (revolute or prismatic),
- j_2 = number of two-degrees-of-freedom joints (higher pairs).

For a basic four-bar linkage:

$$DoF = 3(4-1)-2(4)$$
$$=1$$

The Gruebler's equation is used to calculate the degrees of freedom for planar mechanism, which is $DoF = 3(n-1) - 2j_1 - j_2$.

The number of links j_1 is number of degrees of freedom joint and j_2 is for number of 2 degrees of freedom joints on a higher pair. So for a 4 bar mechanism, you try to get degrees of freedom as 1.

Four-Bar Linkage

This confirms that **a four-bar linkage has one degree of freedom**, making it a single-input mechanism.

Drive → input
o/p → Sewing

Explanation and Application to Four-Bar Linkage:

- Gruebler's equation shows that in a four-bar linkage, the motion of one link (typically the crank) controls the motion of the entire mechanism. This property makes four-bar linkages suitable for applications requiring precise motion control, such as in engines, robotic arms, and various machinery.

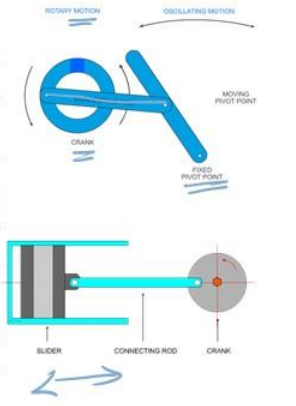
This confirms that the 4 bar mechanism has 1 degree of freedom making it a single input mechanism. That means to say you drive 1 input so that you get the output whatever it is. Output can be sweeping or windshield cleaning.

So, explanation and application to four bar mechanisms. Gruebler's equation show that four bar linkage, the motion of one link controls the motion of the entire mechanism. This property makes four bar linkage suitable for various applications in engine, robotic arm and various machinery. It is also used for precision motion control.

Motion Analysis of Four-Bar Linkage

Types of Motion:

- **Rotational Motion:** In a four-bar linkage, one or more links may exhibit continuous rotational motion. This is typically seen in the crank, which rotates fully about its pivot.
- **Oscillatory Motion:** Some links may exhibit oscillatory motion, where they rotate back and forth over a limited angle. This motion is commonly observed in the follower or coupler when they are constrained by the linkage geometry.
- **Translational Motion:** Although less common in basic four-bar linkages, certain configurations or extensions (e.g., slider-crank mechanisms) can produce translational motion, where a link moves in a straight line.



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What are the different types of motion you can try to have with the four bar mechanism? You can try to have a Rotational Motion, an Oscillatory Motion, a Translation Motion. Rotation Motion, you can see that there is a crank which rotates, there is a connecting rod which connects between this and then you have a link which is a fixed pivot and then an Oscillating Motion.

So Rotating Motion, Oscillating Motion. Some linkages may exhibit oscillatory motion, pendulum clock, where they rotate back and forth over a limited angle, pendulum clock over a segment. The motion is commonly observed in the follower or coupler when they are constrained by a linkage geometry.

Translational Motion, translation is sliding. Although less common in basic 4-bar linkage, certain configuration or extensions can produce translational motion where the links move in a straight line.

Kinematic Pairs

- Mechanisms can be considered as "kinematic chains" assembled from elementary kinematic pairs formed by two rigid bodies in direct contact. The analysis of mechanisms depends on studying these kinematic pairs and the specific relative motion they allow between two interconnected rigid bodies.
- **Lower Kinematic Pairs:** These occur when the connection between two bodies is realized through a surface of contact maintained between them. They are one of the two main classes of kinematic pairs.
- **Higher Kinematic Pairs:** These involve contact between lines or points of the two bodies. This is the other main class of kinematic pairs.

So, moving further in Kinematic Pairs, mechanisms can be considered as a kinematic chain and assembled from elementary kinematic pairs formed by two rigid bodies in direct contact. The analysis of mechanisms depend on studying these kinematic pairs and their specific relative motion, they allow between the two interconnecting rigid bodies. So kinematics we know, we are now seeing Kinematics Pair.

There are two classifications, Lower order Kinematic Pair and a Higher order Kinematic Pair. In a Lower order Kinematic Pair, this occurs when the connection between the two bodies is realized through a surface of contact maintained between them. They are one of the two main classes of kinematic pair. The higher order is, this involves contact between the lines or points of the two bodies. They are called as the Higher Kinematic Pair.

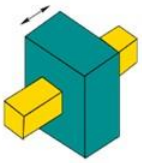
So, the kinematic chain is assembled for elementary kinematic pair formed by two rigid bodies in direct contact. One is surface contact, another one is line or point contact.

Types of Kinematic Pairs

1. **Revolute Joint (Rotary Joint):**
- Allows rotational motion about a single axis. The relative motion between the two connected bodies is purely rotational.
- **Example:** The hinge of a door, the joints in a robot arm

Revolute

2. **Prismatic Joint (Sliding Joint):**
- Permits linear motion along a single axis, allowing one body to slide relative to the other.
- **Example:** The sliding mechanism of a drawer, linear actuators.



Prismatic

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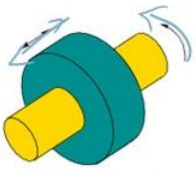
So, types of kinematic pairs, you can have Revolute joints or Rotary joints, the figure is given here. The relative motion between the two connected bodies is purely rotation, which is used in hinge of a door or in joint of a robo. You can have Prismatic joints, which are nothing but sliding joints.

It permits linear motion along a single axis, allowing one body to slide on the other. Like a drawer which is used in the table or a linear actuator falls under prismatic joints.

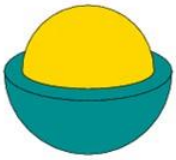
Types of Kinematic Pairs

3. **Cylindrical Joint:**
- Allows both rotational and translational motion along the same axis. It combines the features of both a revolute and a prismatic joint.
- **Example:** A piston moving within a cylinder, telescopic shafts.



Cylindrical

4. **Spherical Joint (Ball-and-Socket Joint):**
- Permits rotational motion about three perpendicular axes, allowing the connected bodies to rotate freely in any direction.
- **Example:** The human shoulder joint, universal joints in vehicles.



Spherical

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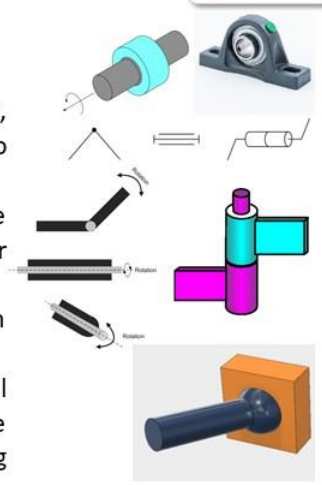
You can have cylindrical joints where they allow a rotation motion and a translation. So, you see a translation and a rotation which is exhaustively used in robots, which is used in piston moving within a cylinder or telescopic shafts.

Spherical joints, Ball and Socket joint is there in your hip and in your arm, permits rotation motion about three perpendicular axes, allowing the connected body to rotate freely in any direction, which is called as Spherical joints.

Types of Kinematic Pairs

Examples in Mechanisms:

- **Revolute Joint:** Commonly used in robotic arms, where multiple revolute joints enable the arm to move in a variety of directions.
- **Prismatic Joint:** Found in linear slides, such as the carriage of a 3D printer, where precise linear movement is required.
- **Cylindrical Joint:** Seen in telescopic mechanisms, such as in some extendable antennas or shock absorbers.
- **Spherical Joint:** Utilized in applications like the ball joints in automotive suspensions, which allow for the free rotation of the wheels while maintaining alignment.



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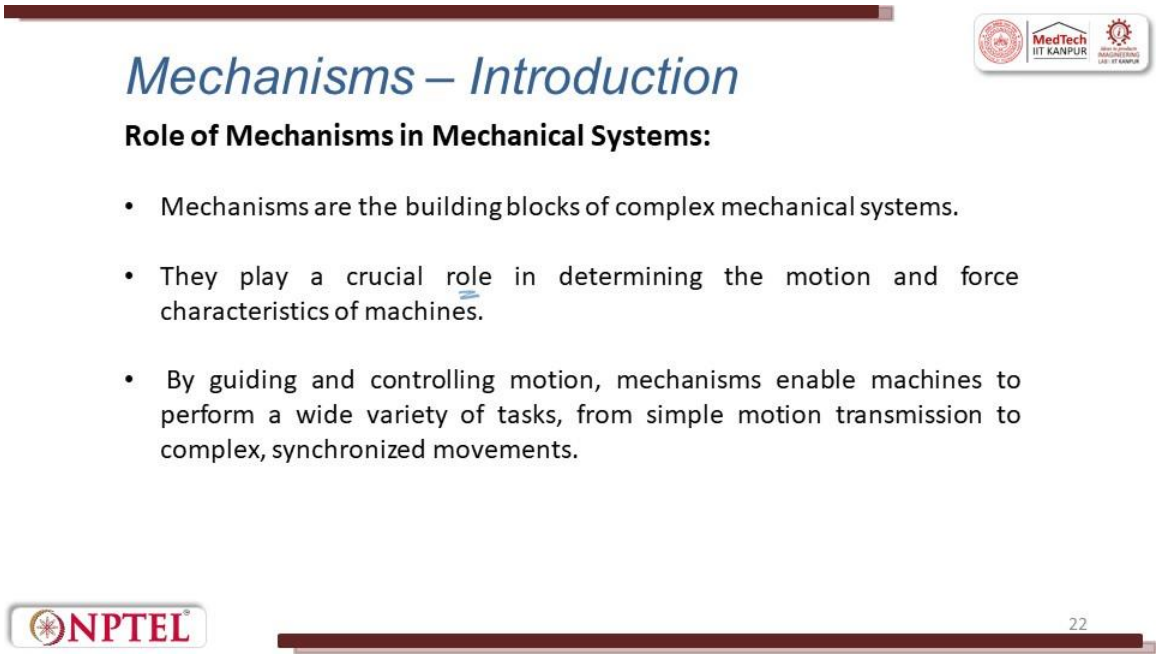
So, examples of revolute joints, robo arm, with multiple revolute joints enables the arm to move in various things. Then Prismatic joint, you can carry it on a 3D printer where the precise linear movement is there.

Cylindrical joints which can be used in telescopic mechanisms like shock absorber and other things. Then you can have Spherical joints which are used in your joystick or in your arm. There can be a ball and then you can try to rotate it.

Applications in Mechanical Systems:

- **Revolute Joints:** Widely used in machinery, robotic arms and mechanical linkages where rotational motion is required.
- **Prismatic Joints:** Essential in systems requiring straight-line motion, such as CNC machines and sliding doors.
- **Cylindrical Joints:** Useful in devices like pistons and telescopic mechanisms where combined rotational and linear motion is necessary.
- **Spherical Joints:** Crucial in systems that require multi-directional movement such as vehicle suspension systems and robotic joints.

Revolute joints are widely used in machineries, robotic arms; Prismatic are used in CNC machines, sliding doors; Cylindrical joints are used in pistons, telescopic mechanisms like shock absorbers; Spherical joints are used in multi-direction movement in a vehicle suspension system or in robotic joints.



So now under mechanisms, role of mechanisms in mechanical systems, mechanisms are the building blocks of complex mechanical systems.

They play a crucial role as discussed. By guiding and controlling motion, mechanisms enable machines to perform a wide variety of tasks.

Mechanisms – Introduction

Importance in Engineering:

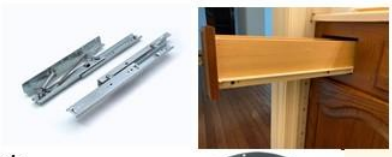
- Mechanisms are fundamental in many fields of engineering:

- **Machines:** Essential for converting energy into useful work, as seen in engines, turbines, and manufacturing equipment.
- **Robots:** Enable precise movements and operations, allowing robots to perform tasks like assembly, welding, and exploration.
- **Automotive Systems:** Found in engines, transmissions, and suspension systems, where they manage motion and force to ensure performance and safety.

So, in different engineering applications, machines, robo, automobile systems, these mechanisms are exhaustively used.

Classification of Mechanisms

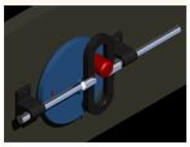
1. Linear Motion:
- Movement in a straight line.
- Example: Sliding drawer, elevator.



2. Rotary Motion:
- Circular movement around a fixed axis.
- Example: Fan blades, vehicle wheels.

3. Oscillatory Motion:
- Back-and-forth movement around an equilibrium position.
- Example: Pendulum, swing.

4. Reciprocating Motion:
- Repeated linear movement back and forth.
- Example: Engine piston, sewing machine needle.



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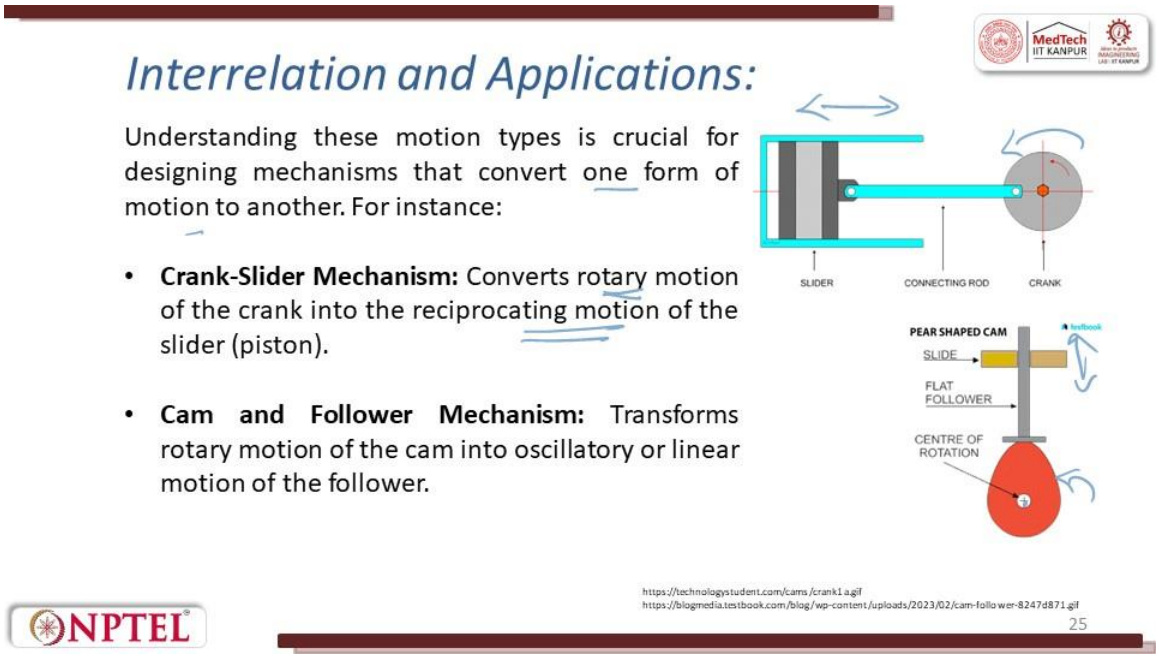
So, some of the classifications of mechanism, Linear motion, Rotary motion, Oscillatory motion, Reciprocatory motion. You can see here Linear motion is a lock which is used, a

sliding drawer, an elevator. Rotary motion, it is rotation motion about a fixed axis, something like a fan or a vehicle wheel.

Oscillatory motion which is back and forth. You can see this, whatever it is, it moves back and forth around a equilibrium position, a pendulum or a swing. Reciprocating motion, repeated linear motion back and forth which is used in engine pistons.

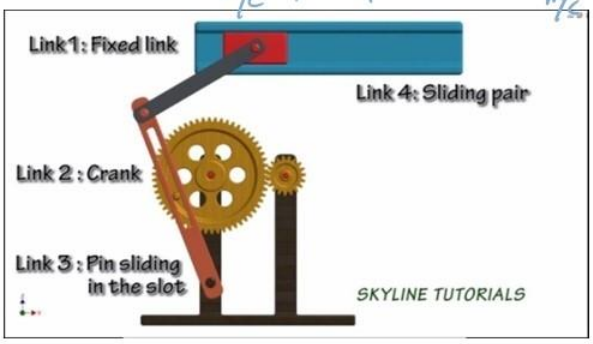


So interrelations and applications. Understanding the motion types is crucial for designing mechanisms that convert one form of motion to the other. So slider crank mechanism or crank slider mechanism. It converts rotary motion of a crank into a reciprocatory motion in a piston.

CAM and follower mechanism transforms rotary of a CAM into oscillatory or linear motion. So opening and closing of some valves can be done by connecting it to a rotary motion.

Quick-Return Mechanism

- A **quick-return mechanism** is a type of mechanical system designed to provide different speeds for the forward and return strokes of a machine.
- The forward stroke typically moves slower, allowing for precise work, while the return stroke moves faster to reduce idle time.



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Quick-return mechanism is a type of mechanical system designed to provide different speeds in the forward stroke and return stroke. This is exhaustively used in machines and in particular it is used in shaping machine. So, what it does is in the forward stroke, it goes at a slower speed.

In the reverse stroke, it goes at a faster speed. So, that is why it is called as Quick Return mechanism because in the return speed, it is a non-productive. So, it has to be done very fast. This type of mechanical systems designed to provide different speeds for the forward and the return. The forward stroke typically moves slower and also precise while the return moves faster where it reduces the ideal time.

Quick-Return Mechanism

Examples:

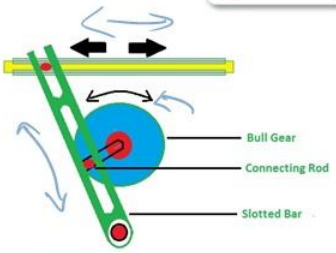
Whitworth Quick-Return Mechanism:

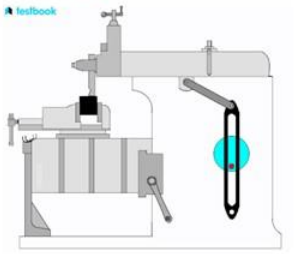
This mechanism converts rotary motion into reciprocating motion with a faster return stroke than the forward stroke. It is commonly used in machinery where efficiency in the return stroke is critical.

Application:

Shaper Machines:

In shaper machines, the Whitworth quick-return mechanism is employed to speed up the return stroke, increasing overall productivity by minimizing the time spent in non-cutting motion.





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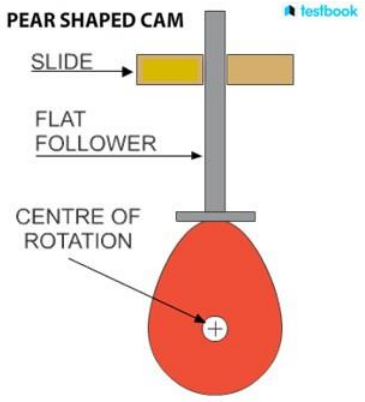
It is called as Whitworth quick return mechanism where in which this is a bull gear which is attached to a motor. So, this gear rotates and then you have a connecting rod. So, this connecting rod is connected to the bull gear like this and then you have a slotted gear. In this, the connecting rod or this point keeps reciprocating up and down. So, this rotates.

This in turn transfers the motion to the stroke length, whatever it is. The mechanism converts rotary motion. This is the rotary motion into a sliding motion or reciprocating motion. In the forward direction, it is slow. Return direction, it is faster.

So application shaping machine, this is how it is. You see a bull gear rotating and you have a slotted bar. This slotted bar is connected to a link. So this is how the in the forward stroke machining happens. Return stroke, it is non-productive. So you get to move faster.

Cam and Follower Mechanisms

- A **cam** is an essential component in mechanical systems, designed to convert rotational motion into linear or oscillatory motion.
- The shape or profile of the cam directly influences the motion of the follower, allowing for precise control of complex movements in various mechanical applications.
- Cams are particularly valuable because they can create non-uniform motion patterns, such as accelerating or decelerating movements, that are difficult to achieve with other mechanical components.



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Cam and Follower, you can see a slider which is there. When the cam comes to the topmost position, it pushes the reciprocating follower and this follower in turn slides inside and then opens and closes. A cam is an essential component in mechanical systems designed to convert rotary motion into oscillatory motion. The shape or the profile of a cam directly influences the motion of a follower, allowing a precise control of a complex mechanisms.

Cams are particularly valuable because they can create non-uniform patterns such as accelerating or decelerating motion. This is exhaustively used in automobiles.

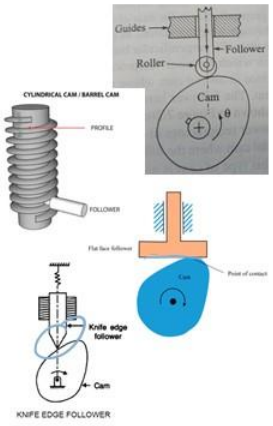
Cam and Follower Mechanisms

Cams:

- **Disk or Plate Cam:** It has a flat disk with a specific profile, commonly used in engines.
- **Cylindrical Cam:** It has a cylinder with a profile cut along its length, used in machine tools.
- **Translating Cam:** It is a cam that moves in a straight line rather than rotating.

Followers:

- **Flat-Faced Follower:** It has a flat surface in contact with the cam.
- **Roller Follower:** It has a rolling element to reduce friction.
- **Knife-Edge Follower:** It has a sharp edge that contacts the cam, offering high precision but prone to wear.



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Disk or Plate cam, it is a flat disc with a specific profile commonly used in engines. Cylindrical cams, it has a cylinder where the profile cuts along the length used in machine tools. Translating motion, it is a cam that moves in a straight line rather than rotating.

So these are all the different types of cam. You can have a disc type, cylinder type, translation type. Follower, there can be a flat faced follower. There can be a roller follower or there can be a knife edged follower. So it has a flat surface in contact.

It basically to try to distribute the load. It has a rolling element to reduce the friction which is a roller and you can have a knife which has a very precise control but it is prone for wear.

Cam and Follower Mechanisms: Applications

Valve Timing in Internal Combustion Engines:

- Cams control the opening and closing of engine valves, ensuring precise timing for intake and exhaust cycles.

Automation Systems:

- Cams are used in automated machinery to control repetitive motions, such as in packaging, textile, and assembly line equipment.

So, valve timing in internal combustion engine is always done by cam and follower. In automation, cams are used in automated machines which can be used in packaging, textile and in assembly lines.

To Recapitulate

- Define a linkage. Differentiate between planar and spatial linkages.
- What is a four-bar linkage?
- Calculate the Degree of Freedom for a planar four-bar linkage using Gruebler's equation.
- What is a mechanism? Describe the kinematic chain.
- Explain the function of a quick return mechanism.

To recap what we have seen in this lecture, we saw what is a linkage, what are the different types of planar and spatial linkage, what is a four bar linkage, then degrees of freedom calculation, what is mechanisms and kinematic chain, what is a function of a quick return mechanism. I am sure you would have enjoyed this lecture and henceforth when you look at any machine or a door, you should always look for what is the linkage and what is the mechanism.

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The references used for this lecture are listed here.

Thank you.