Introduction to Internet of Things
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Lecture – 04
Actuation

So, this particular lecture is on actuation. So, based on the readings of the sensor, we have already seen different types of sensors in the previous lecture and based on the readings of these different types of sensors, some action might be required to be taken and that is done by actuators. These actuators basically perform certain actions on the environment on another system on a device and so on.

So, there are different examples of actuators. I am going to show you a different type of actuators very shortly, but these actuators, they can have principle of working principles which are based on electronics, then electrical, then you know mechanical systems and so on. So, they basically you know use some kind of control behavior, some control signals are sent. So, this is how these actuators, they perform.

We are going to go through the different mechanisms behind the functioning of these actuators in this particular lecture.

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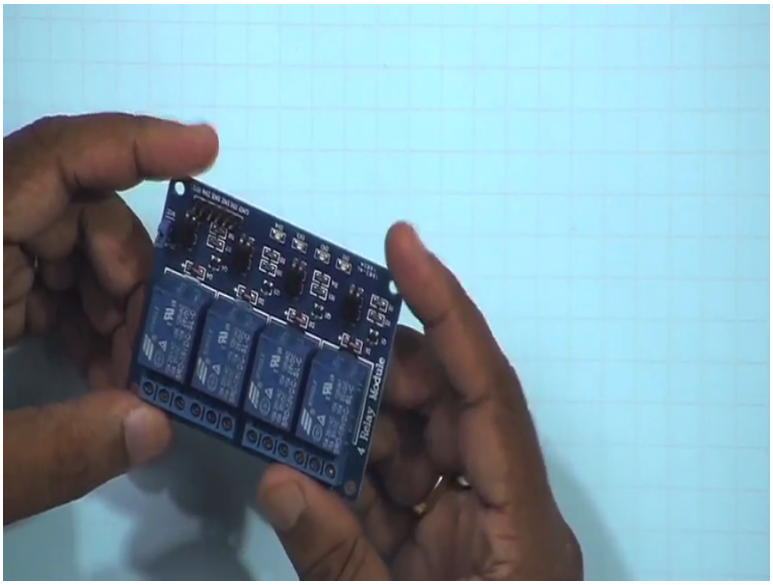

Before we proceed, I wanted to show you at the outset some of these actuators that can be used. So, here is an example of a sample actuator which is known as the relay switch. So, this relay switch, it is an electromechanical switch which can be used to switch between AC and DC for instance or different other things can be performed. So, the sensor networks, the sensor nodes, they typically operate in DC and based on the sensed value maybe you know you want to switch off the electricity in your room or at your home based or maybe something, maybe fire has been detected by the sensor network, then you want to do something or you want to turn off the power in your home.

So, that is AC that operates on AC, right. So, this particular switch, this electromechanical switch will basically turn off AC that the power supply at your home. This can help in doing it. So, this is an example and this is known as relay.

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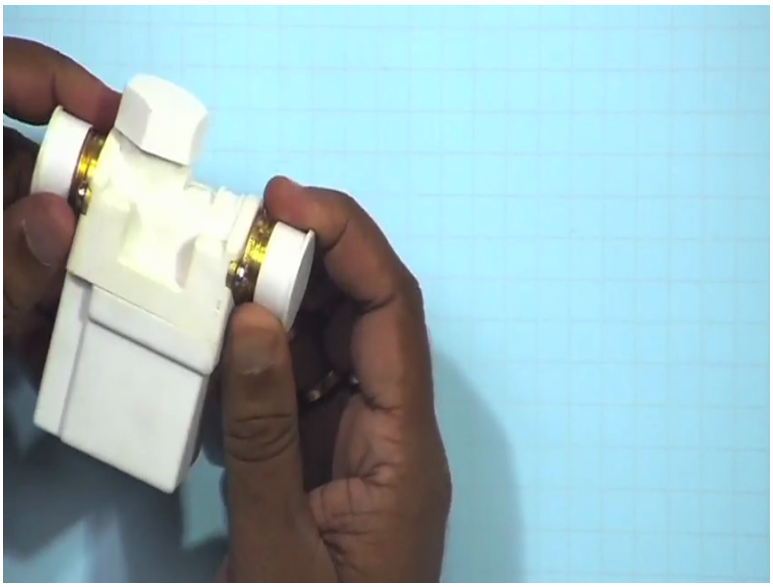

There is another one which is the solenoid valve and this basically can help in controlling the flow of liquid. So, you have an input; you have an output. So, we have an input, we have an output and the solenoid valve if we open it, so what we can see over here is what is inside. So, you know water can flow in and depending on the conditions, this valve is going to either allow the water to flow out or it is going to stop. It is not going to allow.

So, this is another actuator. Like this there are different actuators that are available for use in IoT. So, having seen some real life actuators, let us try to understand the basic principles of actuators, but before that let us go through some of the basics.

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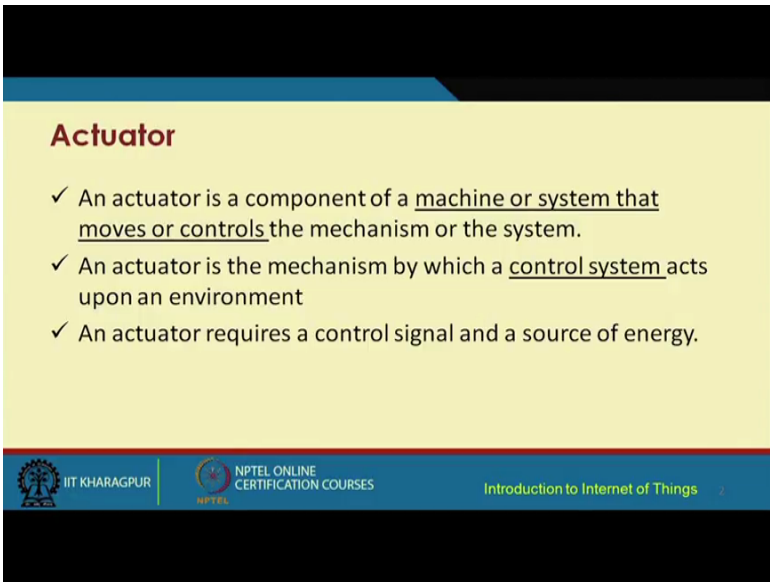

So, an actuator is a component of a machine or a system that moves or controls the mechanism of the system. So, typically these actuators are based on some control system and these control systems, they act on the environment. So, an actuator basically requires some kind of a control signal and a source of energy for their functioning.

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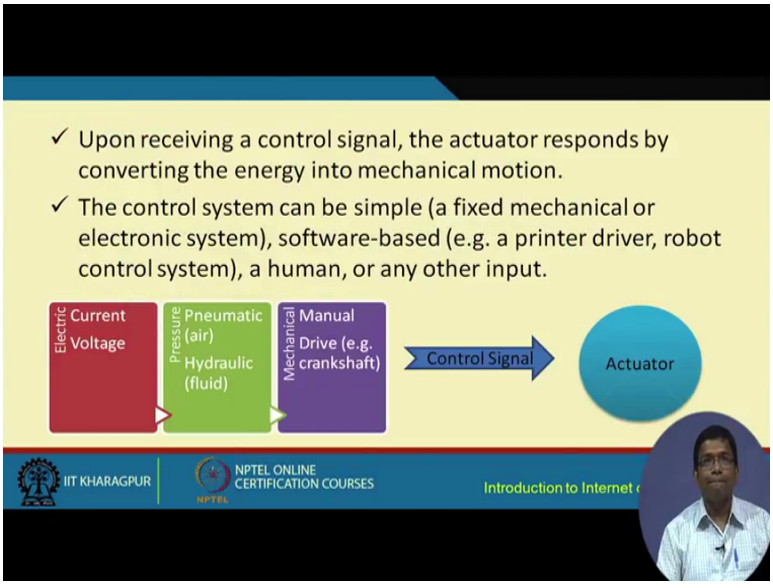

So, typically I said that control signals are required for the actuators. So, when these actuators receive a control signal, they respond by converting that energy into mechanical motion. Some mechanically something is going to be done. This is an

example of course. So, they convert that electrical signal, some control signal into mechanical motion and that control system can be simple which can be based on some mechanical or electronic system or it can be software based like a printer, driver, robot, control system, a human or any other input.

So, what we have are three types. One of actuators, one is these electric based actuators. We have this pressure based actuators and we have these mechanical based actuators. Each of these, they send control signals and based on that the actuation is going to be performed.

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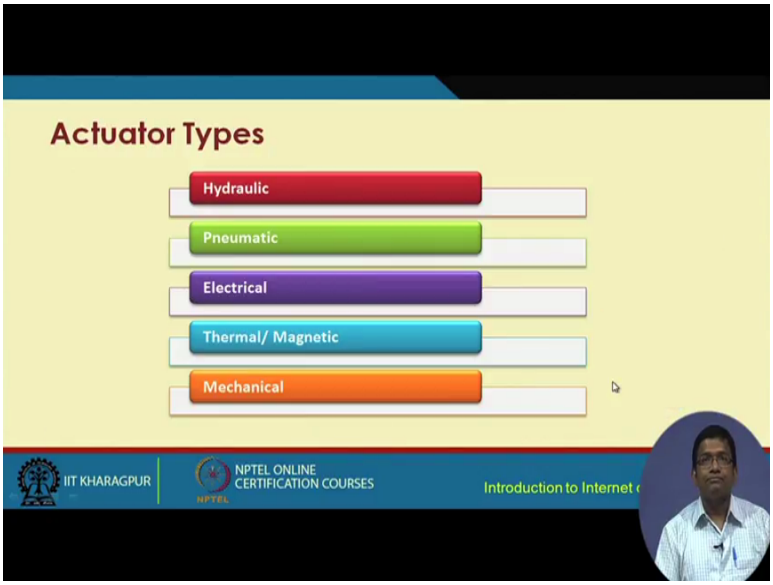

So, we have hydraulic actuators, pneumatic actuators, electrical actuators, thermal actuators, magnetic actuators and mechanical actuators.

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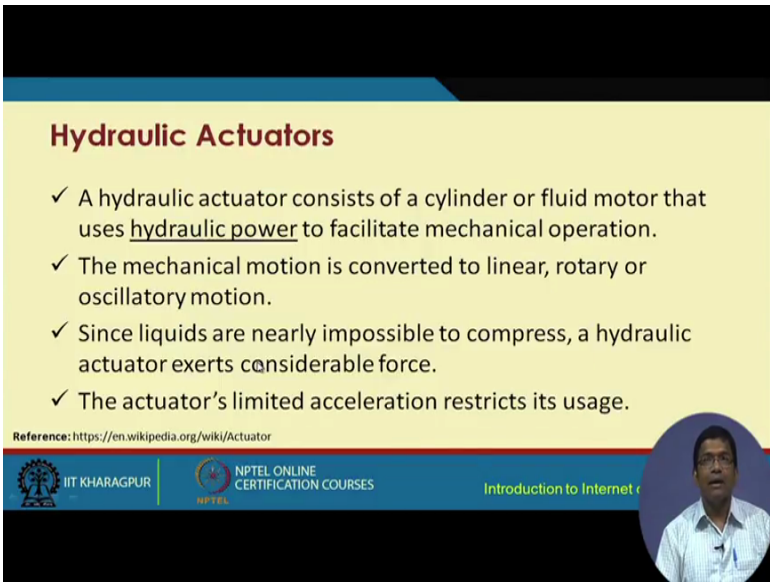

So, this name suggests, these hydraulic actuators consist of a cylinder or fluid motor that uses hydraulic power to facilitate mechanical operation. The mechanical motion is converted to linear rotary or oscillatory motion.

So, basically you know when some fluid passes through, then you know that motion is converted to some linear motion or some oscillatory motion or rotary motion and since liquids are nearly impossible to compress, most of the hydraulic actuators basically exert considerable force. So, that is the reason why liquid based actuators are typically used you know. So, these are quite popular because of this particular reason.

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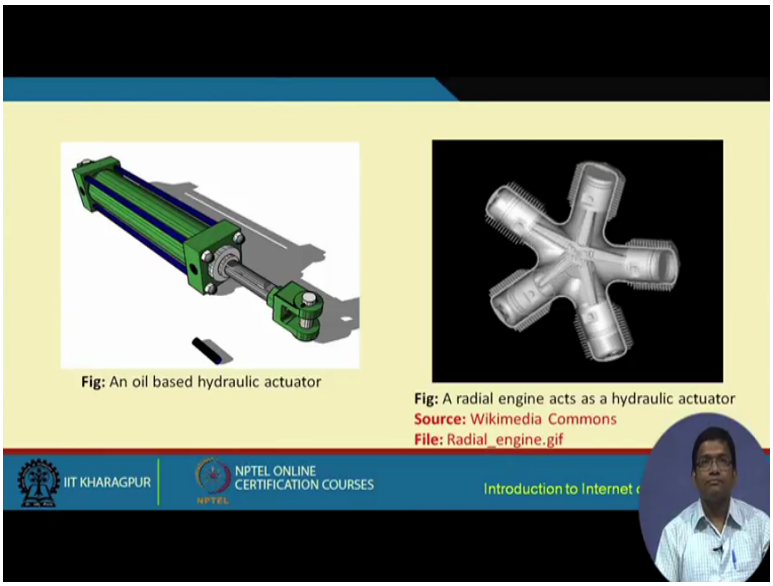

On the left hand side, we see an example of an hydraulic actuator which is based on the use of oil. So, in this particular cylinder, oil will be there and then, when you put, when you apply pressure on it, it is going to give an output based on which there can be some linear motion or some oscillatory motion or rotatory motion or whatever that can be performed.

So, here on the right hand side, we see over here a figure which shows an hydraulic actuator based an hydraulic actuator, based on radial engine. So, as we can see over here, this is quite. This animation is quite. You know it is quite explanatory. So, as we can see over here you know liquid goes inside and when you synchronize the liquid going inside from these different directions, then what happens is you can emulate a rotatory motion like this. So, this basically can help in the functioning of an engine. So, it can give a rotatory motion in this manner.

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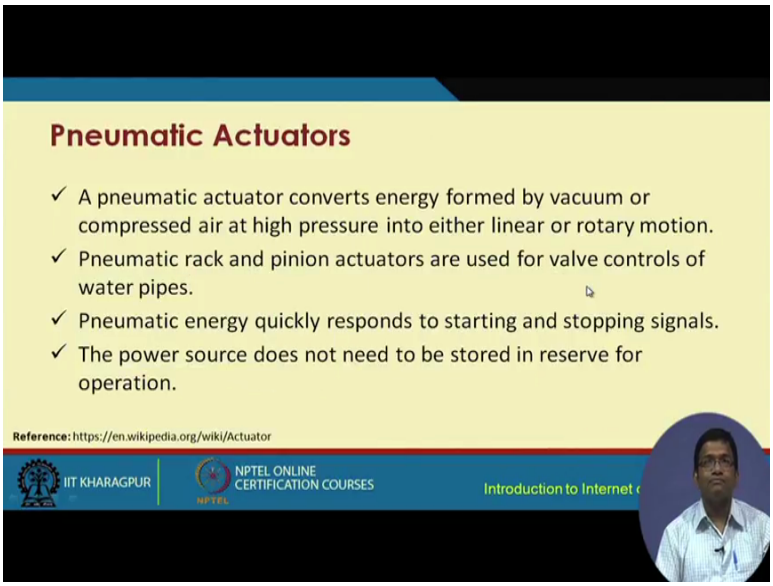

So, those were the hydraulic actuators. Pneumatic actuator, pneumatic means air based. A pneumatic actuator basically converts the energy formed by vacuum or compressed air at high pressure into either linear or rotatory motion.

So, you know the rack and pinion actuators are typically the pneumatic actuators and these are used for valve controls of water pipe, water pipes. Pneumatic actuators basically exert a lot of force and for example, the pneumatic brakes can be very responsive to small changes in pressure that are applied by the driver.

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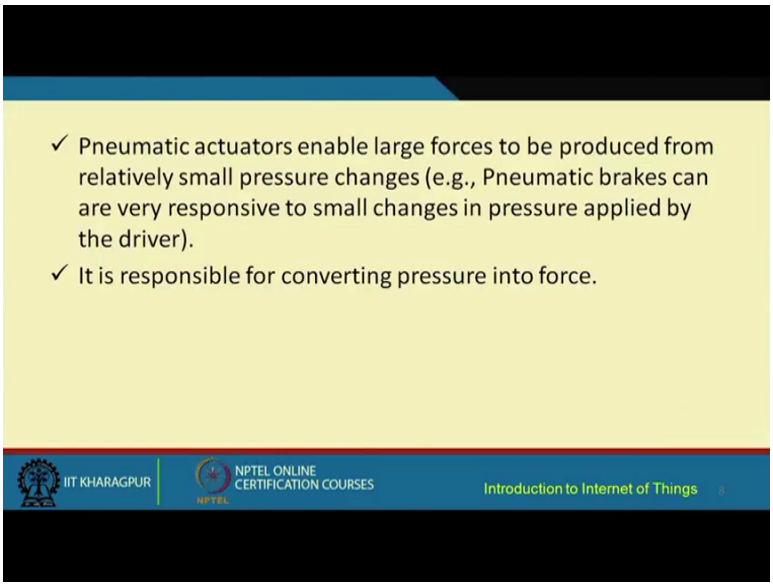

So, pneumatic brakes are quite common in different like trucks etcetera. They use pneumatic brakes. So, hydraulic brakes are more common in cars, in trucks. The pneumatic brakes are quite common.

So, these pneumatic brakes, the advantage is that they are very responsive to small changes. You know if the X-ray, if the brake is pressed little bit, you know they become, they act quite fast. This is an advantage of these pneumatic actuators. So, basically what happens is the pressure that is put on the brake that is converted into force pretty fast. So, this is one of the advantages of these pneumatic sensors.

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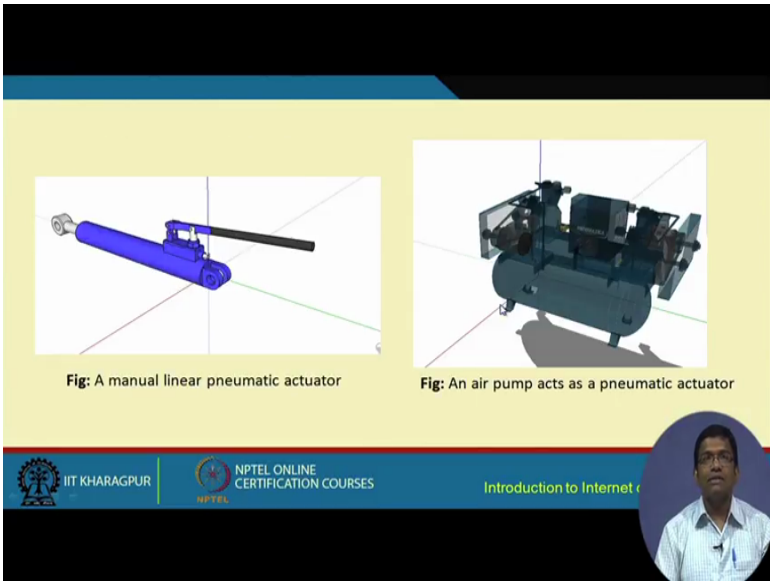

So, here is a figure of a pneumatic sensor when you apply pressure over here. So, this shaft, this crankshaft or this shaft will move and this is an example of a pneumatic actuator.

So, basically this is a figure which shows an air pump acting as a pneumatic actuator and then, we have seen hydraulic actuators, we have seen pneumatic actuators.

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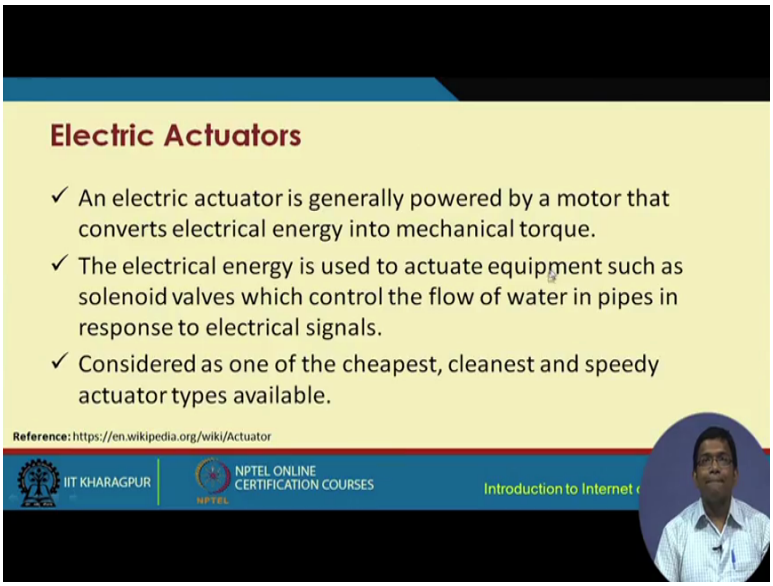

Then, we have the electric actuators. An electric actuator is generally powered by a motor that converts electrical energy into mechanical torque. So, this electrical energy is used to actuate the equipment, such as the solenoid valve which control the flow of water in pipes in response to electrical signals and this is what I was showing you at the outset. I showed you one of the actuators. The solenoid valve I had shown you and this basically works on the principle of electrical actuator.

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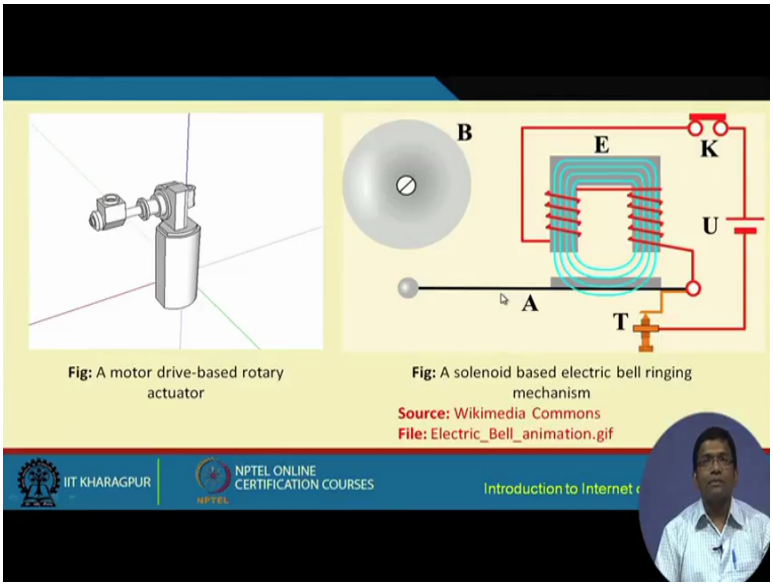

So, on the left hand side is a figure showing a motor drive based rotary actuator. So, basically you know what happens is this basically you know the electrical signal over here will help in moving this. So, it is going to give a rotary motion of this particular part. So, this is an example of a motor drive based rotary actuator. Here in this particular animation what you see is an electric, the functioning of an electric bell. An electric bell is an example of a solenoid based actuator.

So, as you can see over here once the bell is pressed, then the connectivity is established and then, the electromagnetic field is generated due to which the bell sounds and this is the way in which solenoid based electric bells functions. So, these are two examples of electrical electrical actuators.

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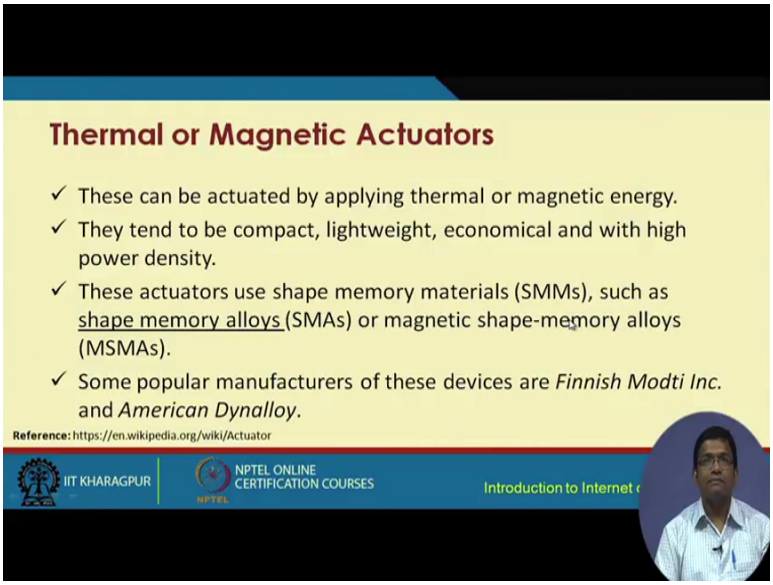

Then, we can have thermal or magnetic actuators which can, so thermal or magnetic actuators, these can be actuated by applying thermal or magnetic energy and typically, they are very popular because of being that they are very compact, lightweight, economical and with high power density.

So, these active actuators use shape memory materials or shape memory alloys SMAs and this is very popular at present.

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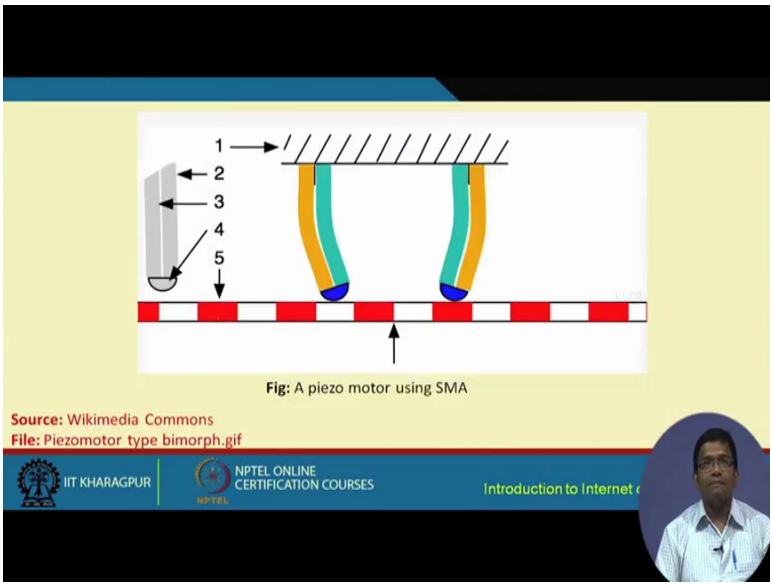

So, this is how it works. So, this is an example of an SMA based piezo motor. So, as you can see over here, these are the different steps in which it works. So, these are two metal strips and when you know when the energy is passed through it, they bend and when they bend, they basically move this red and white strip mechanically. So, this basically acts as an actuator.

So, this is like a joint metal bar and this is like this, sorry. So, when you heat this metal bar, this is an alloy bar consisting of two metal strips. So, you know the property is that when you heat it, then it is going to bend and when it bend, it is going to move this particular strip in this manner. So, the different steps are shown over here and this is quite evident, it is quite explanatory from these steps.

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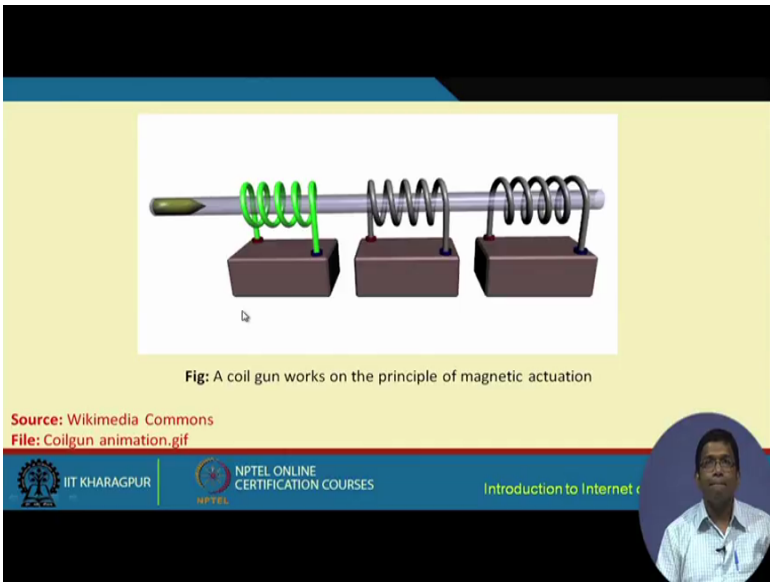

So, this is an example of a coil gun which basically works on the principle of magnetic actuation. So, this is also quite explanatory. So, this coil gun you know. So, basically you know electromagnetic field is generated and then, you know again it is pushed and so on.

So, basically you know functioning of the hyper loops, at present people are talking about hyper loops, right. So, presenting if the functioning of the hyper loops are also you know based on this particular principle.

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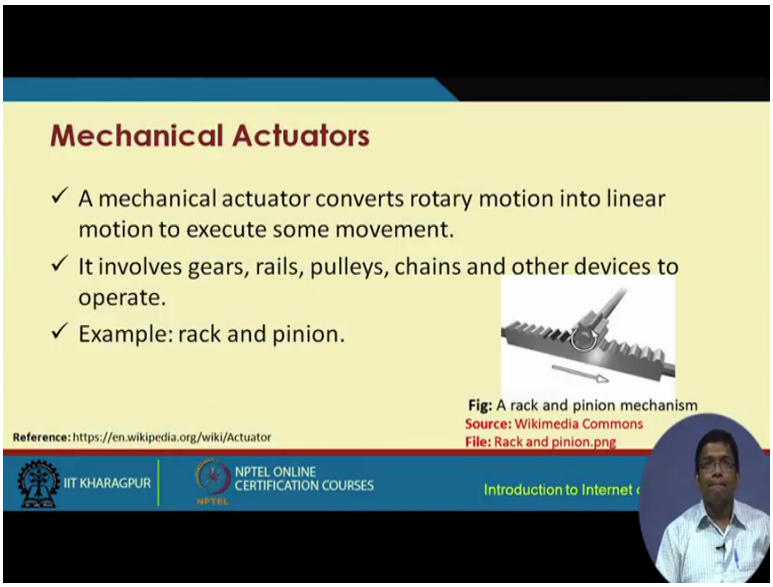

Then, we have these mechanical actuators which basically converts rotatory motion into linear motion to execute some movements. So, this basically involves these gears, the pinions, gears, pinions rails, pulleys, chains and other devices to operate. So, rack and pinion is an example of a mechanical actuator. The figure shows it and it is quite exponentially from this.

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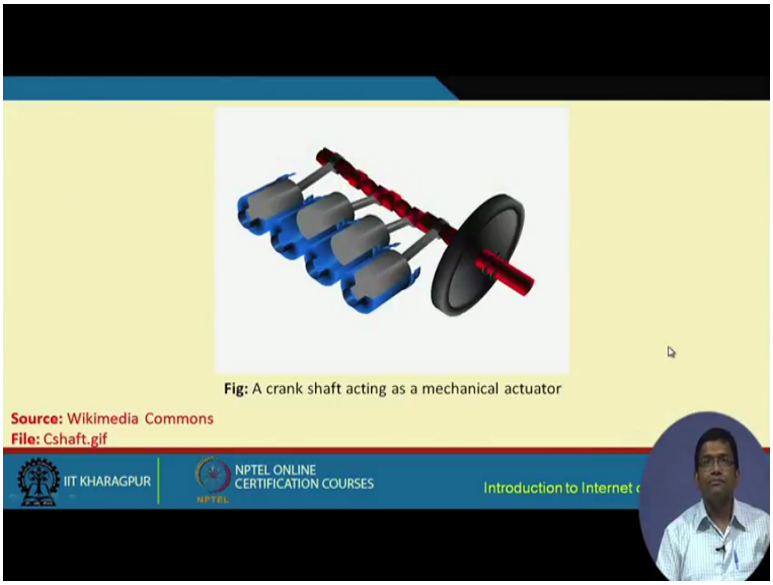

So, as it moves, basically this also moves. So, a crankshaft is another example of a mechanical actuator. So, this is how the crankshaft works.

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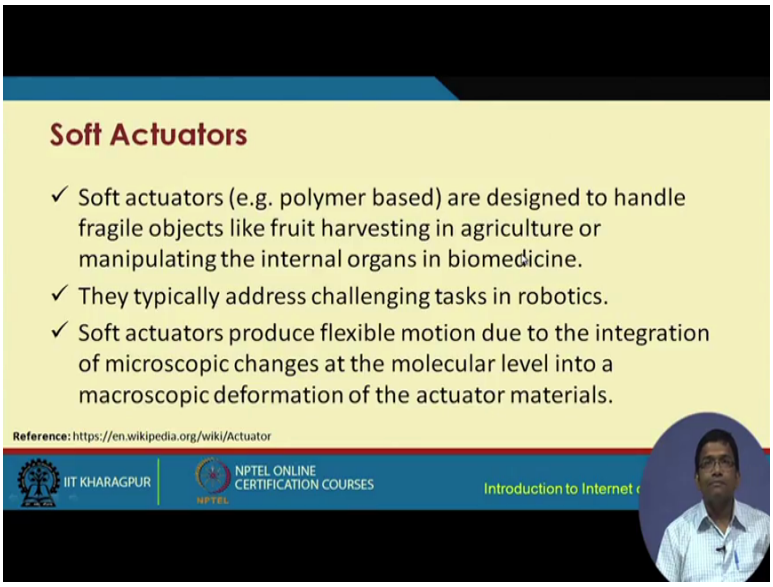

So, as this thing moves in this manner, so this gives this one a mechanical motion, a rotatory motion. There are different soft actuators which are actually polymer based and the design to handle fragile objects like fruit harvesting in agriculture or in biomedicine, handling internal organs of human beings and typically these are used in robotics. So, soft actuators are also quite popular.

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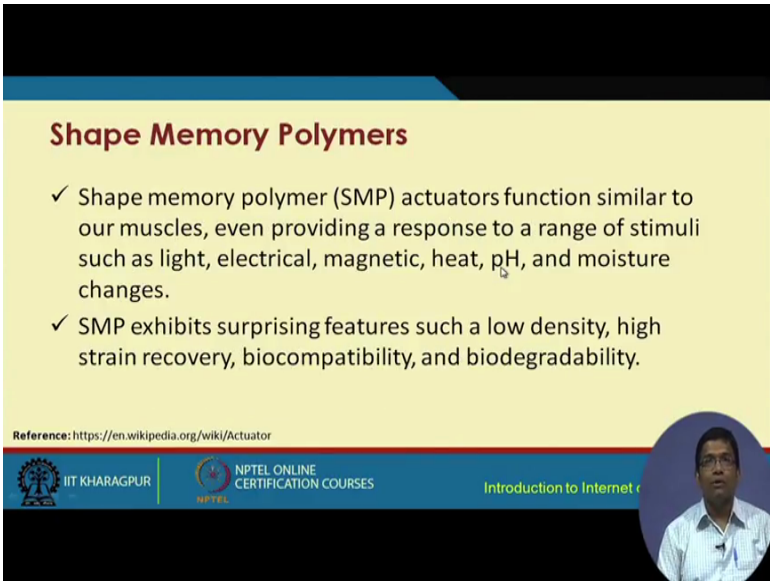

These basically use something known as SMP, the Shape Memory Polymers which are actually polymers and the behavior of the polymers will change depending on the stimuli. The stimuli for these polymers are the light, electrical signals, magnetic signals, heat, PH etcetera. They have different properties. These polymers, they behave differently due to these different variations in these physical properties.

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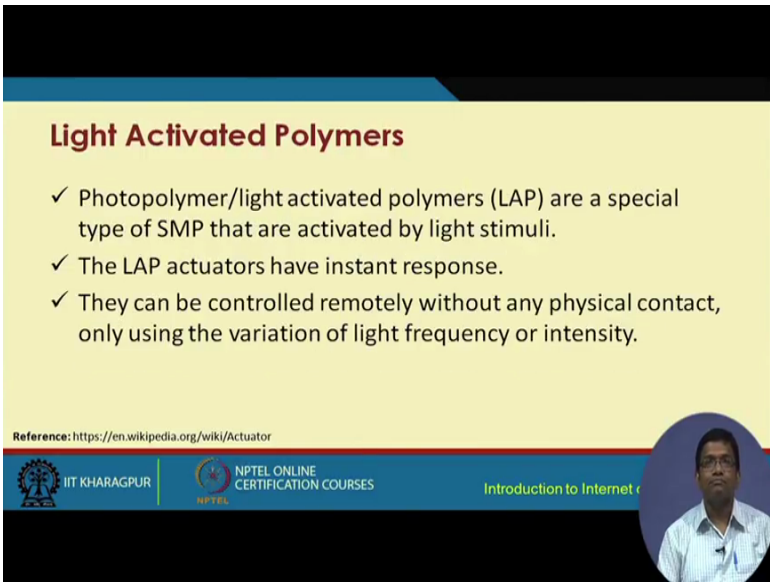

Then, we have the light activated from polymers. These polymers basically get activated through light stimuli and these are also quite popular. So, what we have seen are different actuators, their actuation principles and different diagrams and figures of them and at the outset, we have already seen some real actuators that can be used for building IoT based systems.

Thank you.