Mechatronics
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Lecture – 02
Mechatronics System Examples

Welcome you all on this NPTEL Online Certification Course on Mechatronics. Today, we are going to discuss various examples of mechatronic systems. In last lecture, I have talked a lot about the introduction part of it, I introduced the course to you and today, we are going to see various Mechatronic System Examples.

So, initial two examples I have taken from our daily life equipments and the next two examples are from small robotic kit with the help of which I will be trying to explain you what are the various mechatronics component in it.

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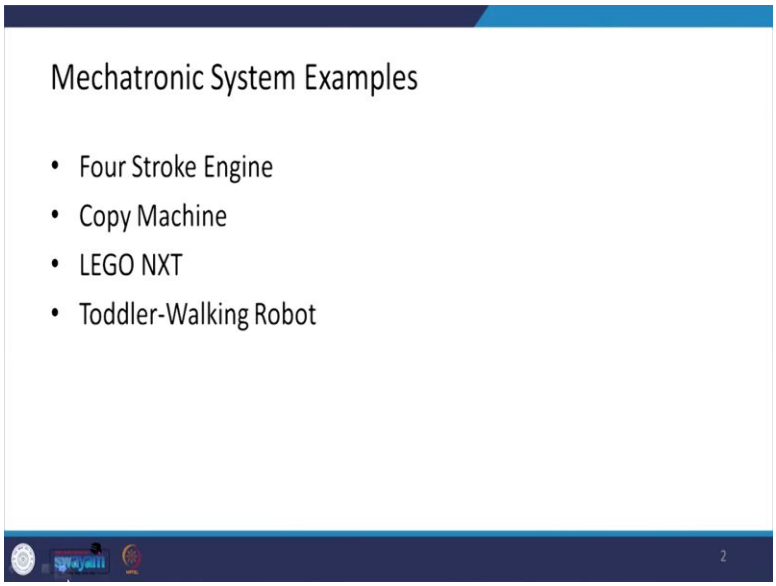

So, the first one is a four-stroke engine where we will be seeing how the mechatronics helped us in making a proper ignition timing and air fuel ratio mixture to be sent to the engine.

Similarly, in the second example in a copy machine, we will be seeing what the various steps in copying are and how mechatronics helps us in doing all those steps. And as I said next two examples, Lego NXT is a mobile robot kit basically supplied by Lego and similarly toddler,

small walking robot is again a kit with the help of which we can simply understand the various mechatronics components.

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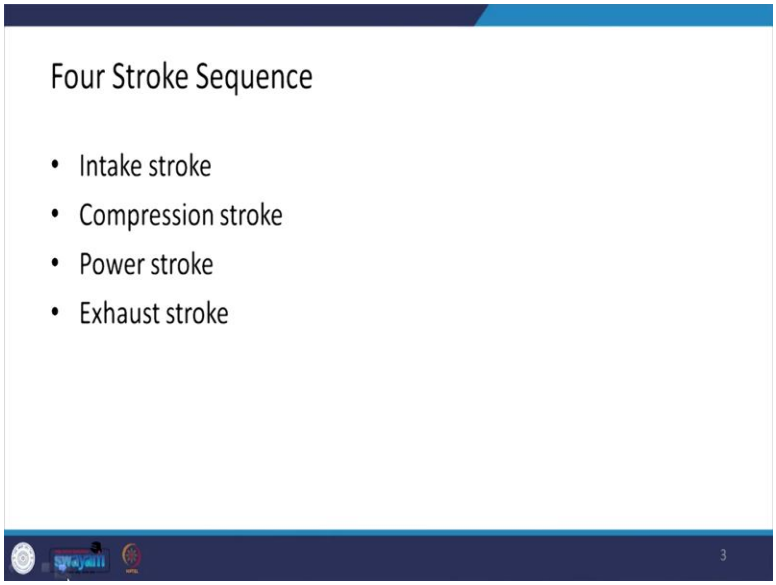

So, coming to the first example that is the four-stroke engine, let us look at what are the various four-stroke sequences. So, these four-stroke sequences are intake stroke, compression stroke, power stroke and exhaust stroke. So, let us have a look at it.

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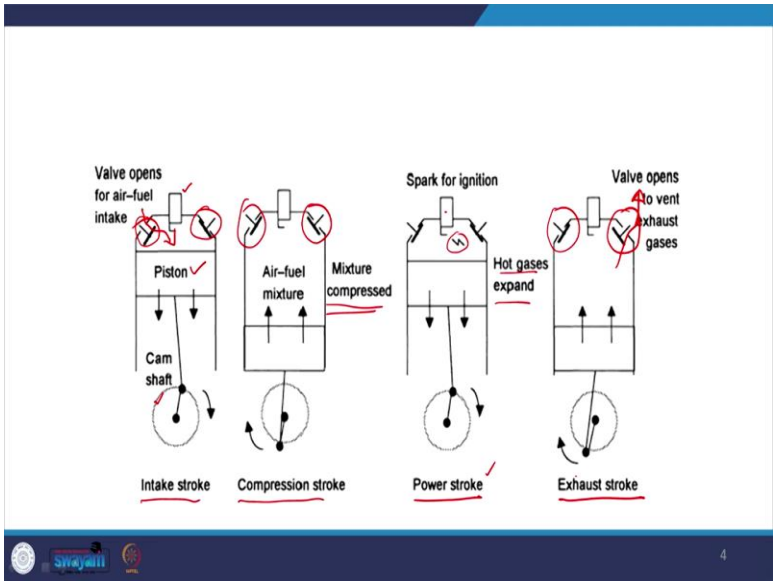

Here, in this figure, we can see the various four-strokes are mentioned intake stroke, compression stroke, power stroke and the exhaust stroke. So, we can see in this figure the

various component we have piston and we have cam shaft here, you can see that there is a spark plug for ignition and there are two valves; one is the intake valve, and another is the exhaust valve.

So, in intake stroke as you can see that this intake valve is open and we get the mixture, air fuel mixture into it like this and after that the piston keeps on moving downwards. So, that completes the intake stroke when it reaches to the bottom most position and then takes the compression stroke.

And in compression stroke what happens? We have the intake valve gets closed and naturally your exhaust valve is already closed so, you can see the closed position for the intake valve and exhaust valve and then with the motion of the piston, air fuel mixture gets compressed basically that is why this is called the compression stroke. So, we have the mixture being getting compressed.

Next is the power stroke. Now, in power stroke what happens? There is an ignition which is given by the spark plug. So, spark plugs gives the ignition here this is the spark plug and again in this position both the valves are closed and after ignition, the air fuel ratio that is there is the burning of the fuel here and those burnt gases they expand basically. So, hot gases expands and because of that, we have a motion of the piston and the cam shaft rotates. So, this is how we get the power stroke.

And in exhaust stroke what we can see that the exhaust valve gets opened as you can see in this figure and your exhaust gas come out from over here and in this case, our intake valve is remains closed. So, these are the four steps that is the intake stroke, compression stroke, power stroke and exhaust stroke.

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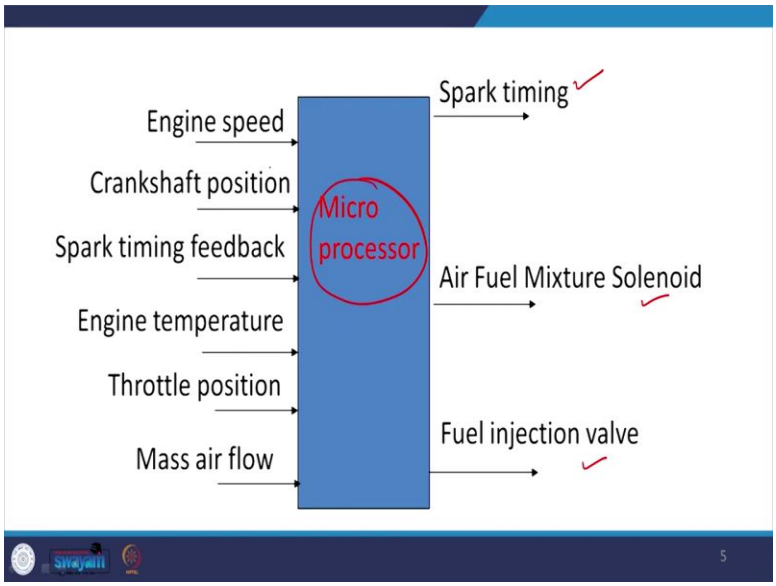

And with the help of mechatronics, what is done is that we try to control spark timing, we try to control air fuel mixture and we try to control the fuel injection ok. So, we have a actually microprocessor as you can see in the this block diagram, there are various input parameters over here. For example, we have engine speed, crankshaft position, spark timing feedback, then engine temperature is there, throttle position is there and mass of mass air flow is there ok.

Now, the output of the microprocessor system is the spark timing, air fuel mixture and of course, this controls your solenoid here that is mixture controlled through solenoid and there is a fuel injection valve.

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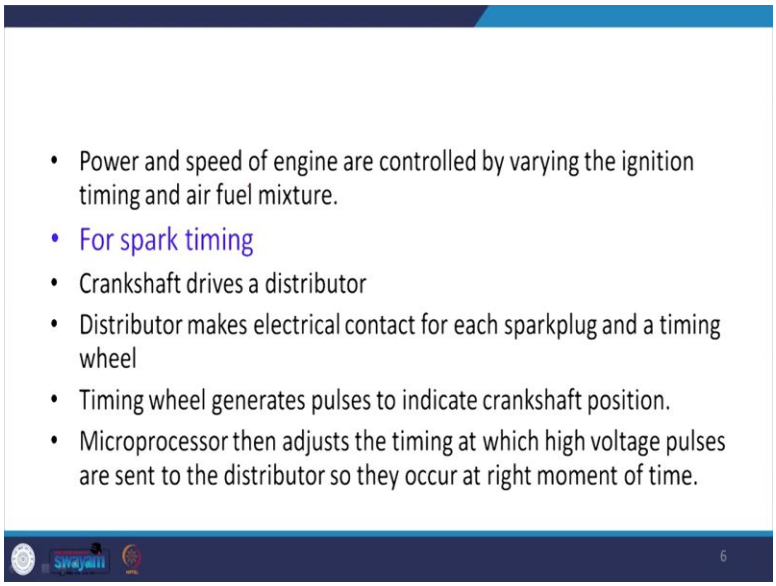

So, the power and speed of engine are controlled by varying the ignition timing and the air fuel mixture ok. So, what happens actually? For spark timing what is done is that crankshaft drives a distributor and distributor makes electrical contact for each spark plug and a timing wheel.

Now, timing wheel generates pulses to indicate the crankshaft position and then the microprocessor adjusts the timing which high voltage pulses are sent and the to the distributor so, they occur at the right moment time. So, this is how spark timing is controlled with the help of microprocessor.

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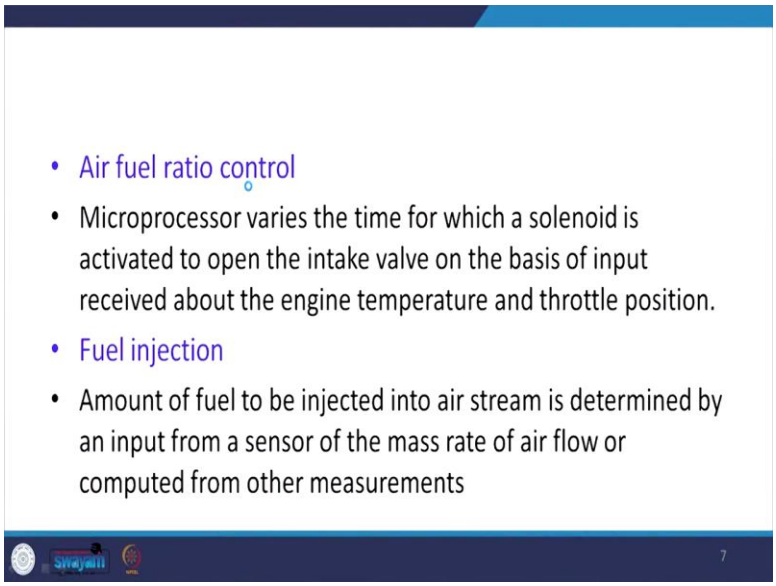

Similarly, for air fuel ratio control, what is the done is that microprocessor varies the time for which a solenoid is activated to open the intake valve on the basis of input received about the engine temperature and the throttle position. So, with engine temperature and throttle position as the input, microprocessor controls the opening of the solenoid valve ok. So, this is how it is done.

Then similarly, we have the fuel injection control. Here, the amount of fuel to be injected into the air stream that is determined by an input from a sensor of the mass flow rate of air flow or it may be computed with a from various other measurement. So, this is how mechatronics help us in the speed and the power control of the engine ok.

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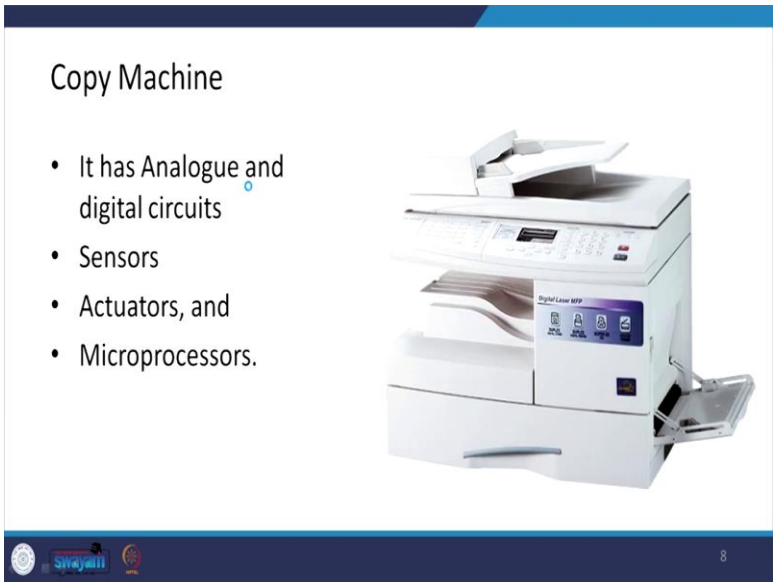

So, next example is another a very popular example of the copying machine. The copying machine has got both analogue as well as digital circuits. There are many sensors in it, there are actuators and there are microprocessors. So, essentially, we have all the components of a mechatronic system in a copy machine.

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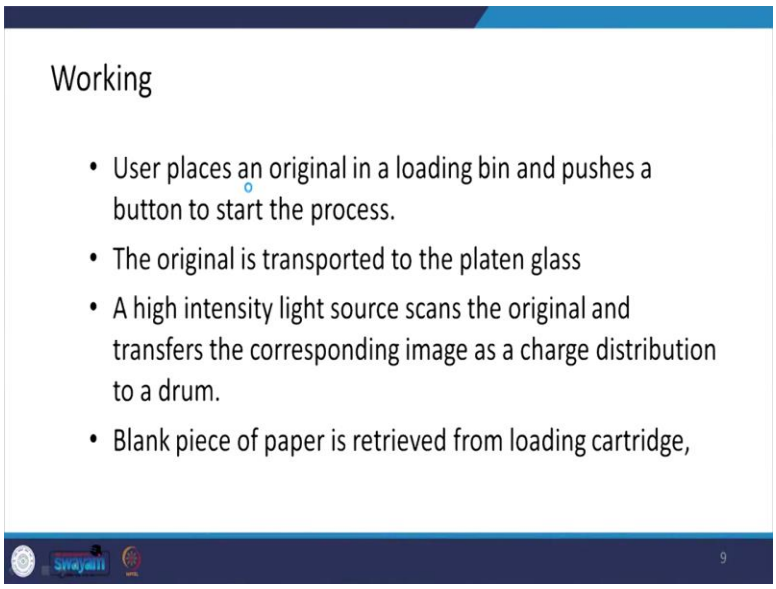

If we look at the working of the copy machine, here are the various steps first of all what one does is that is the user places an original which is to be copied in a loading bin and pushes button to start the process.

Now, what happens next is that the original is transported to a platen glass and a high intensity light source scans the original and transfers the corresponding image as a charge distributor to a; charge distribution to a drum. Now, the blank piece of paper is it retrieved from a loading cartridge.

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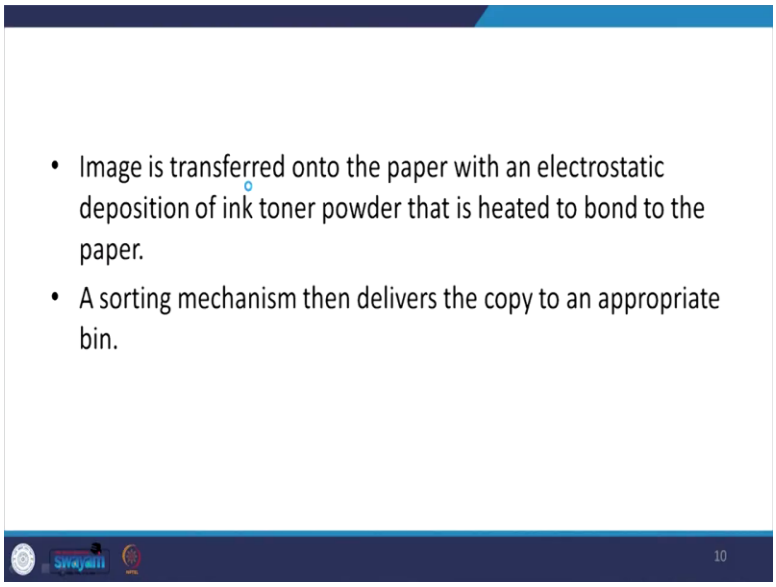

And then, the image is transferred into that blank paper with an electrostatic deposition of ink toner power powder that is heated to bond to the paper and then finally, a sorting mechanism delivers the copy to an appropriate bin. So, these are the steps in a copying machine.

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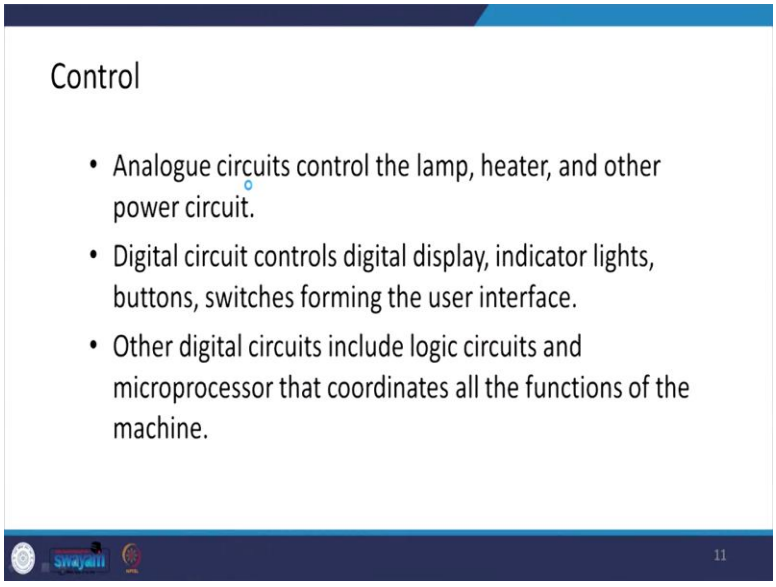

Now, here if we look at it, how the control takes place basically in this mechatronic system? So, the analogue circuit controls the lamp, the heater and other power circuits and the digital circuit controls the digital display, indicator lights, buttons, switches from the user interface. Other digital circuit includes logic circuit and microprocessor that coordinate all the functions of the machine.

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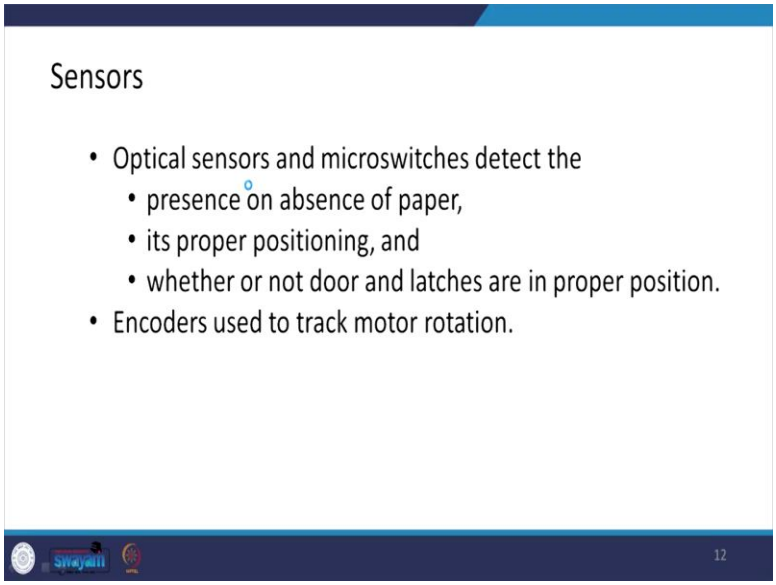

Now, what are the sensors in this? There are optical sensors and micro switches to detect the presence or absence of paper whether the paper is present or not, its proper positioning, so that you get the proper copy of it and whether or not door and latches are in proper position. So, for these optical sensors are used and the encoders are used to track motor rotation. So, these are the sensors which are used in this mechatronic system.

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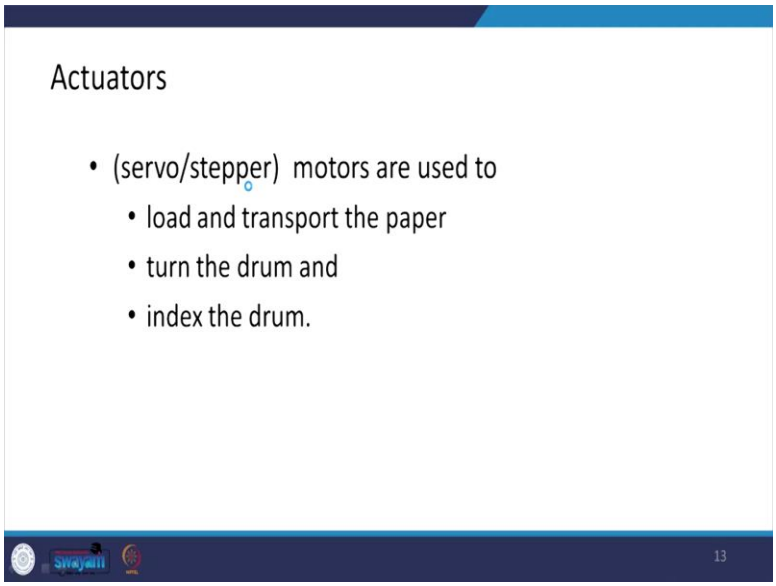

Coming to the actuators, there are servo motors and stepper motors which are used to load and transport the paper turn the drum and index the drum ok. So, these are the that is the three operations for which the actuators are used and we may have servos as well as the stepper motor for this purpose.

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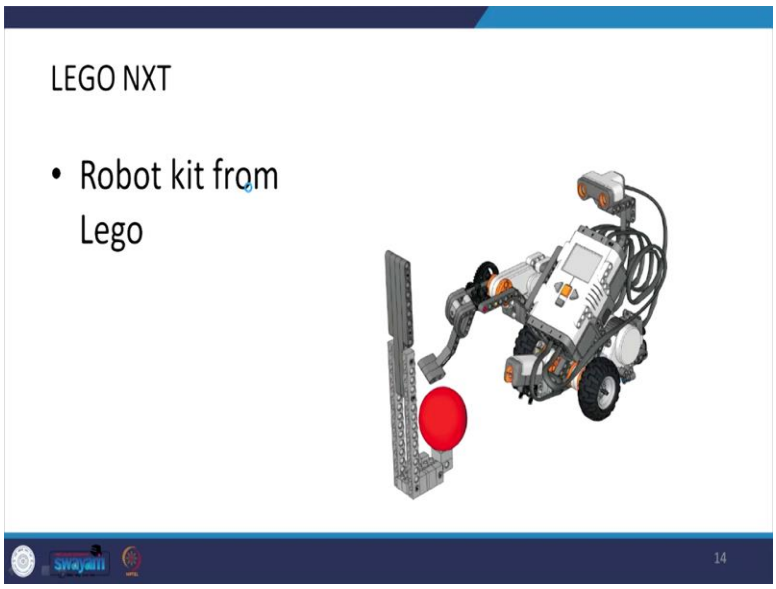

Next example which I want to talk about is the Lego NXT. So, it is basically simple kit which these days many in many labs basically these kits are used just to demonstrate what various

mechatronics components here are ok. So, this robotic kit is from Lego. So, here again we will be seeing the various actuators, sensors and the control controller.

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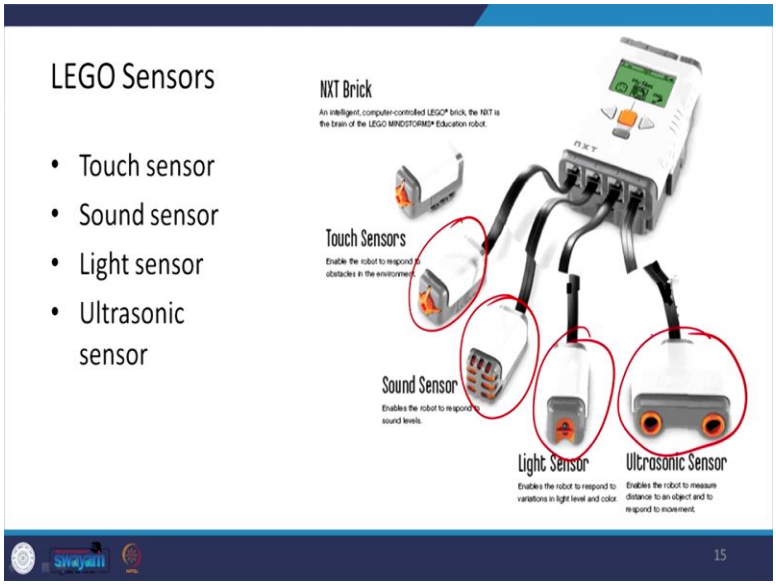

So, coming to what are the Lego sensors available in this so, there is a touch sensor, there is a sound sensor, there is a light sensor and the ultra ultrasonic sensor is there ok.

So, the touch sensor basically enables the robot to respond to obstacles in the environment. Sound sensor enables the robot to respond to various sound levels similarly, the light sensor enables the robot to respond the variation in light level as well as color and ultrasonic sensor enables the robot to measure distance to an object and to respond to the movement. So, these are the various sensors which you can see the touch sensor, sound sensor ah, light sensor and you have the ultrasonic sensor.

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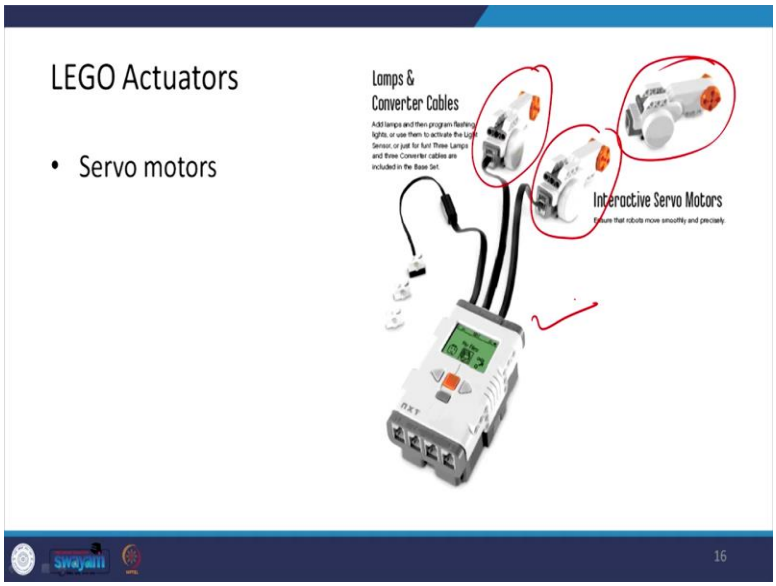

Coming to the actuators, so servo motors are there. So, here with the kit, the three servo motors are provided and these servo motors can be connected through the controller over here ah. So, these servo motor ensures that the robot moves smoothly and precisely.

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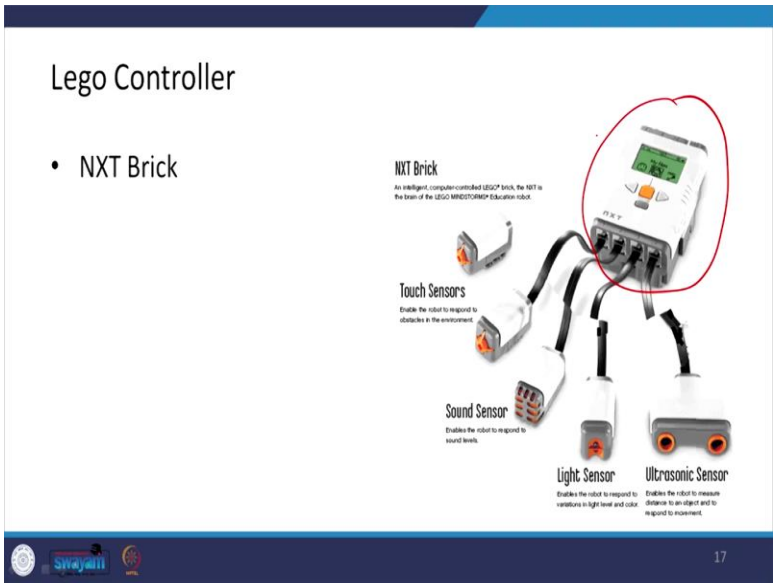

So, we have actuator, we have sensors, and we have the Lego controller which is a NXT brick. So, this part is basically the controller part or what we call it as the NXT brick, this is an intelligent computer control Lego brick, the NXT what we can say is that the brain of the Lego mind-storm educational kit.

So, these days, these kits are available at very reasonable cost and one can very easily program these kits and one can generate the various type of robots for example, you can make a walking robot, you can make some legged robot, you can make a mobile robot out of all these kits and you can do the programming either directly through the brick or you can do the programming through the software which is provided along with the kit through your computer.

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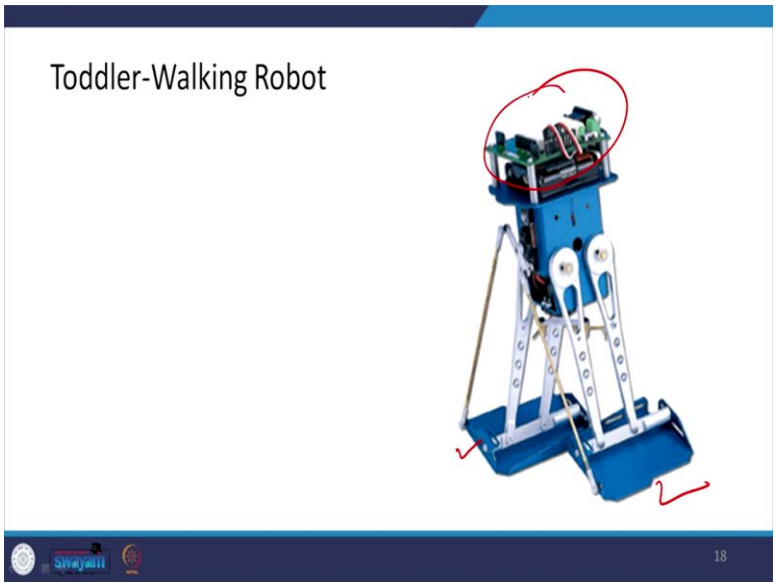

Next example is the toddler-walking robot which I want to talk to you. It is a basically a two-legged robot and again, there are various mechatronics components in it, there are sensors, there are actuators and there is a microcontroller as you can see here and there are sensors.

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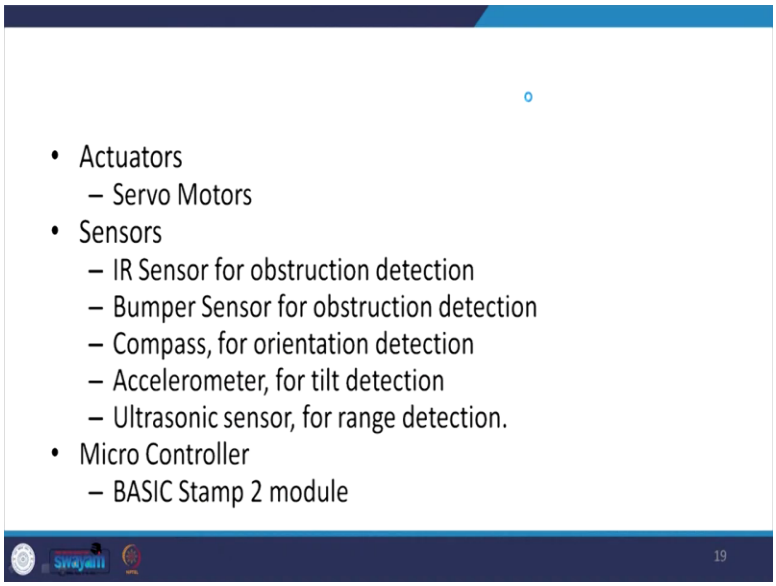

So, actuators here are servo motors which are being used and the sensors which are attached with this kit are IR sensor for obstruction detection that is infrared sensor, then we have the bumper sensor for obstruction detection. Basically, these bumper sensors are nothing but the just like switches basically so, they make on and off contact ok.

Then, we have compass for orientation detection, we have accelerometer for tilt detection and ultrasonic sensor for range detection ok. So, we have actuators, we have sensors and these actuator, sensors are connected through the microcontroller which is here the basic stamp two module ok. So, this way is this toddler-walking robot forms a complete mechatronic system.

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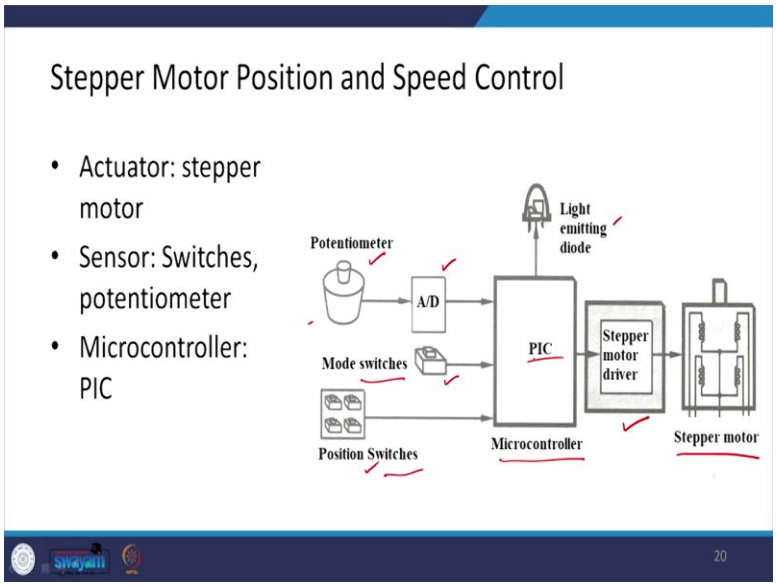

Similarly, we can look at stepper motor position and speed control ok. Now, if we look at this figure, here we see we have a say stepper motor, here there is a stepper motor driver and this driver is connected through a PIC microcontroller and then we have modes for input that is a potentiometer, then we have one analogue to digital converter is there, there are mode switches and there are position switches and you have the light emitting diode here just to see the working of it.

So, the actuator here is the stepper motor, then sensors are here, we have switches are there, then potentiometer is there and the microcontroller is the PIC microcontroller ok. So, the stepper motor position and speed control this also we can take it as an example of the mechatronic system where we have sensor, actuators as well as the microcontroller.

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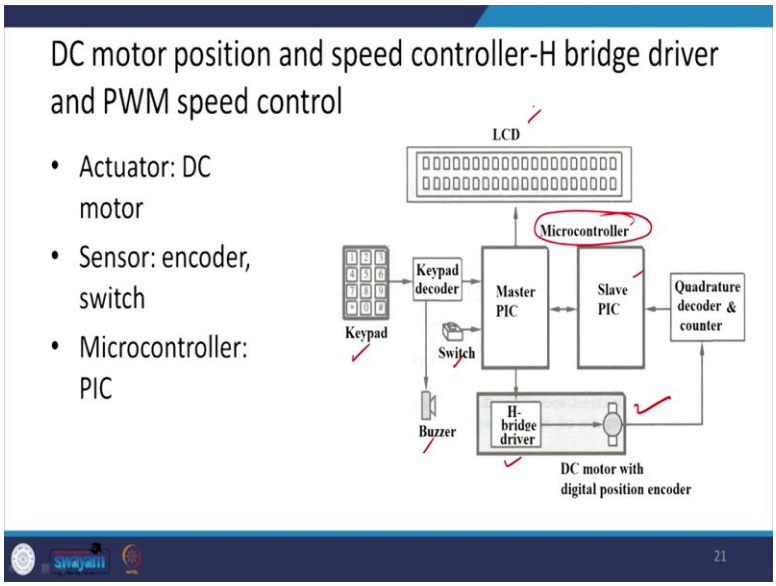

Next another example I wanted to tell you where the DC motor is being used as an actuator ok. So, here the DC motor position and speed controller that is through H-bridge driver and pulse width modulation speed control that is PWM control.

So, here, we can say there is a DC motor with digital position encoder; these encoders are the sensors ah. I will be talking about much more about how the encoders work, what are various type of encoder in the section when I will be talking about the sensors.

So, there is a H-bridge driver here and the encoder signals are sent to the quadrature decoder and counter and then, these signals are sent to the slave PIC, we have a master PIC. So, these master and slave PIC are nothing, but they are the microcontroller and then for input we have keypad is there, switches are there and whether our keypad action is going taking or not that can be seen, that can be identified with the help of buzzer and we have a LCD display.

So, here, we have the actuator as the DC motor, then we have the sensors that is the encoder and switches and the microcontroller is the PIC ok. So, PIC type microcontroller is there.

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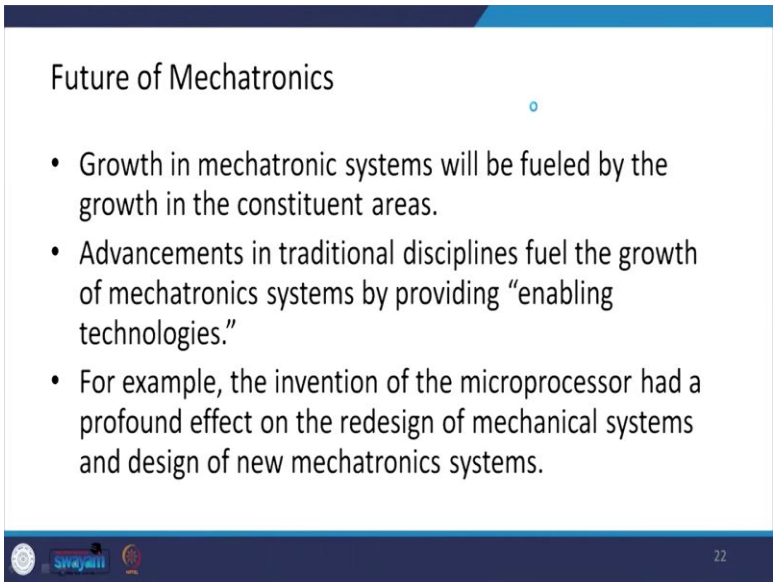

Now, after seeing all these examples, let us talk a little about what is the future of mechatronics, the course which we are going through studying ok. So, the growth in mechatronic system definitely will be fuelled by the growth in the constituent areas ok. So, the constituent areas are actuators, sensors and the microcontrollers.

So, advancement in traditional discipline fuel the growth of mechatronic system by providing the enable enabling technologies. For example, invention of the microprocessor had a profound effect on the redesign of mechanical system and design of the new mechatronic systems.

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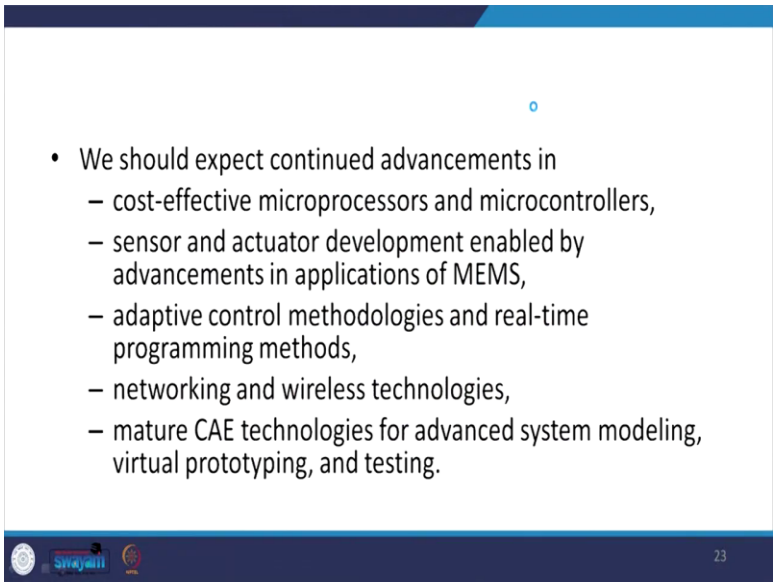

We should expect continuous advancement in as I said cost-effective microprocessor and microcontrollers , then the sensors and actuator development enabled by advancement in applications of say MEMS, adaptive control methodologies and real-time programming methods, networking and wireless technologies and mature CAE technologies for advanced system modelling, virtual prototyping and testing.

So, these days you see we have further advance with what we call it as the internet of things which has come basically with the development of networking and wireless technologies and these are these our many of the mechatronic systems have become controllable with the help of these.

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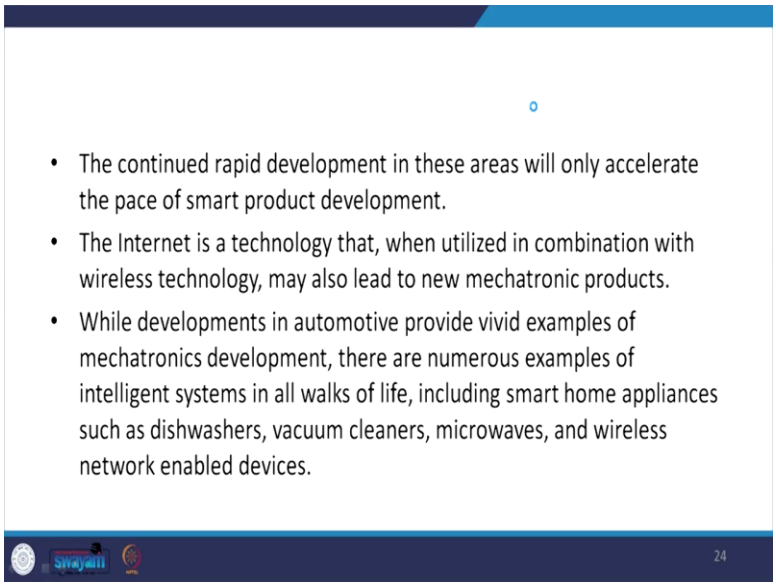

The continued rapid development in these areas will only accelerate the pace of smart product development and as I said internet is a technology that when utilized in combination with wireless technology that may also lead to the new mechatronic products and while as I said earlier, auto mobile sector has been one of the biggest sector which patronized the development of the mechatronic systems.

So, the automotive products will further fuel the growth of mechatronic development, there are numerous example of intelligent system in all walks of life as I said earlier including your smart home appliances such as dishwasher, vacuum cleaner, microwaves and wireless network enabled devices.

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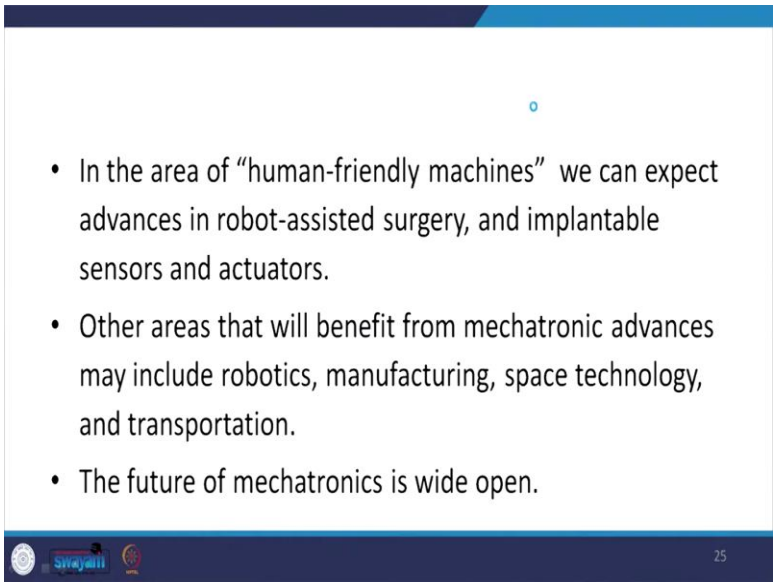

Further in the area of human-friendly machines, we can expect advances in robot-assisted surgery currently we are using say the Da Vinci for the surgery purpose and it has replaced one can say that the laparoscopic surgery and now surgery can be done very easily and further women friendly machines can be made with implantable sensors and actuators.

Other areas that will benefit from mechatronic advances may include robotics, manufacturing space technology transportation and so, we can conclude that the future of mechatronics is wide open and there is a definite need to study this course and try to understand how the more and more mechatronic products could be developed.

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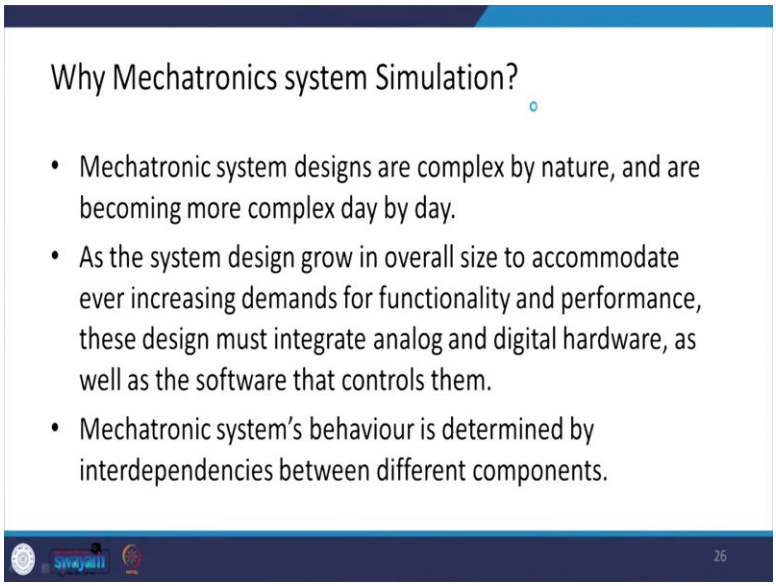

Now, before making any mechatronic product as you know if you may want to make a product, you need lot of resources in terms of time and money has to be spent ok. So, that resources we can use judiciously by going through the mechatronic system simulation ok.

So, the mechatronic system design are complex by nature as we have seen and are becoming more complex day by day and as a system design grows in overall size to accommodate ever increasing demand for functionality and performance, these design must integrate your analogue and digital hardware as well as software that controls them.

And mechatronic system behaviour is determined by inter dependencies between the different components as these components has to be controlled or the inputs has to be taken and output has to be given ok.

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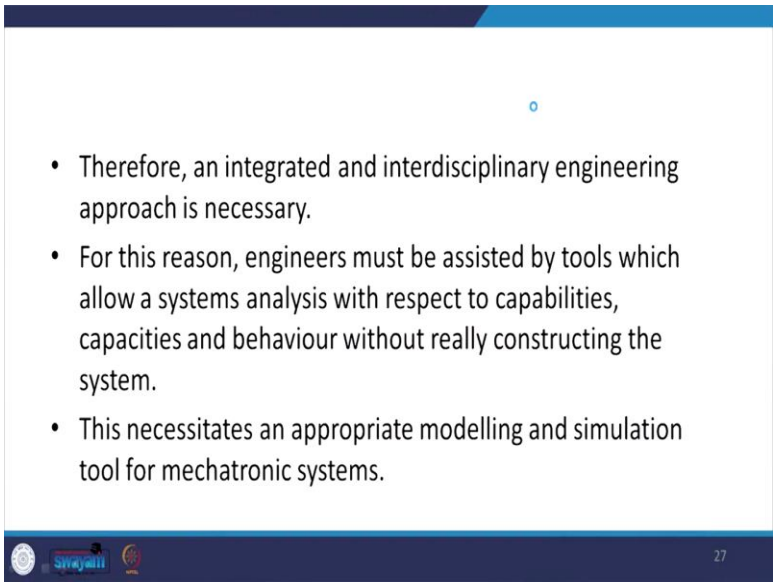

So, therefore, an integrated and interdisciplinary engineering approach is necessary ok. So, for this reason, engineers must be assisted by tools which allows a system analysis with respect to capabilities, capacities and behaviour without really constructing the system ok. So, that without actually making the system, we should be able to see the behaviour of the system and hence comes the need for appropriate modelling and simulation tool for the mechatronic systems.

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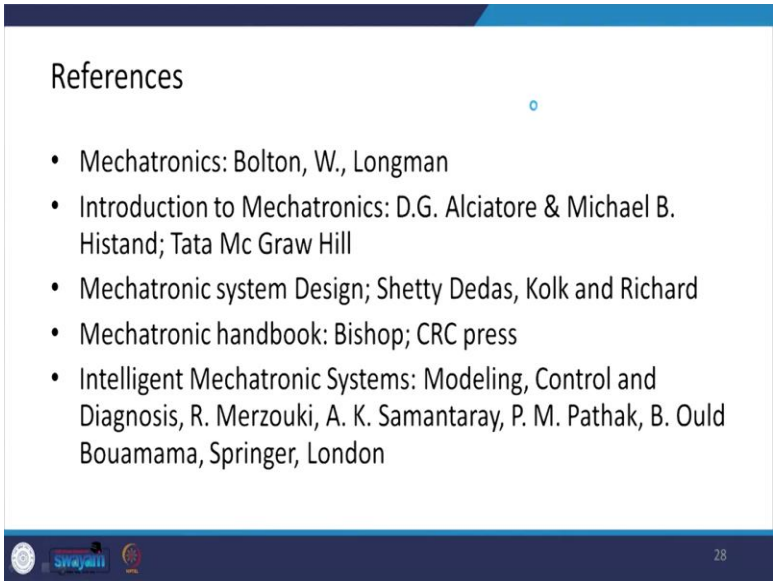

So, here are some of the references which you can look for further study about this. I have talked about these references in my first lecture also that is there is a very good book on Mechatronics by Bolton and another by Alciatore, by Shetty, Bishop as well as you can look at our book also where you will find more of the simulation tools for the mechatronic system.

So, in this lecture, we have seen the examples of the mechatronic systems and so, we have seen the engine control. Then we have seen the photocopier copy machine, we have seen the Lego NXT example, we have seen the legged robot example and we have also seen the stepper motor control as well as the DC motor control.

There could be many more numerous examples as I said this example could be say your dishwasher in your house, it is the automatic washing machine is there ok, the vacuum cleaner in your house is there ok. So, as an exercise, you can take just look at this system and identify how these systems work and what are the various actuators which are used here, what are the various sensors which are used here and what are the what type of controller either microprocessor or microcontroller is being used here.

Thank you and next lecture, we will take up again some of the basics before we actually move on to the actuators and sensors which are used in the mechatronic system, we will be looking at some of the basics. So, I will be talking about some basic concept of electrical engineering, electronics engineering and then we will move on to the our next topic.

Thank you.