Design Practice - 2
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Lecture – 36
Introduction to Mechatronics

Hello and welcome to this design practice to module 36 we are going to talk about introduction to mechatronics with an idea of intelligent product design. So, we will try to decipher a little bit about what are the components which go into mechatronics as a field. How is it different than normal products okay because they are intelligent products and then you apply this mechatronics concept in to developing some of the intelligent products okay.

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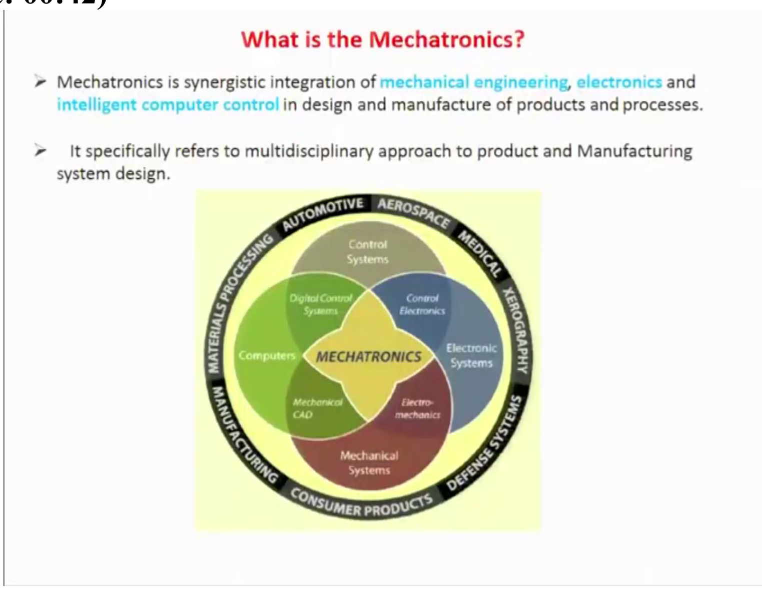

So, let us look into what really is this mechatronics so it is a synergistic integration of mechanical engineering electronics you know intelligent computer control all together. And what we aim to do in this particular course is to design and manufacturing of products and processes which seem to be influenced by all these different domains. And there are many such products which exists particularly let us say a car okay auto motive sector or an airplane these are all intelligent products.

There are controller signals which are being gauged in a manner so that they are able to do their job well through sophisticated computer control okay and a lot of feedback and tailoring the user signal to be doing the job in a manner that it should so that the product performs well. There are many areas you can have automotive aerospace medical equipments, defense systems, consumer products even manufacturing all the CNC processes they are all driven through mechatronics.

And if I have to look at holistically what this area is about it is like a synergism between control systems you know particularly digital control systems control electronics electronic systems electromechanical systems, mechanical systems mechanical cad or computers all integrated together in one domain okay. So, that the idea is that if the user signal is to an extent X can I be able to with feedback improve that signal so that the performance of the system does not get altered too much and it is a fine balance which happens to the real delivery from the product to the real world okay. So it is a very intelligently designed system.

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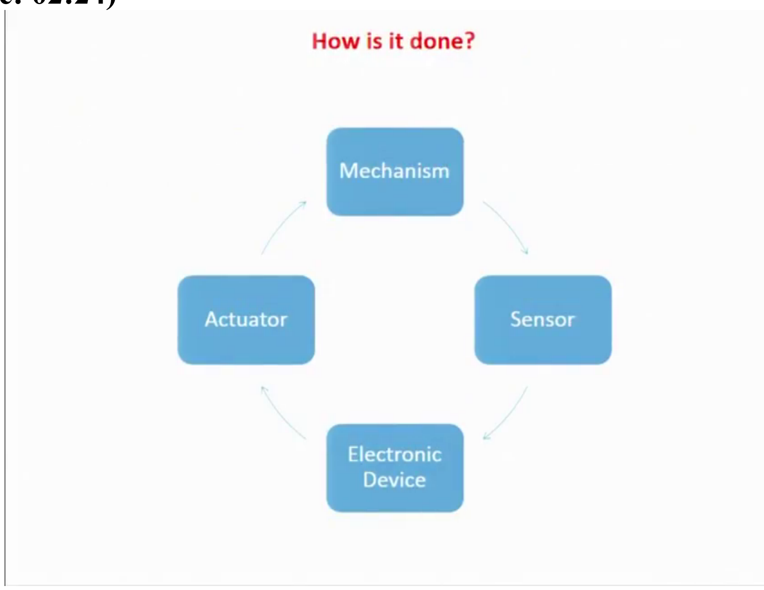

So, how is it done how is mechatronics practiced or how is you know intelligence put into all the products. So, you know you have various components of the system so you have a mechanism in place which is more like the mechanical part of the system of the component. You also have you know an actuator which drives this mechanism. So, this is really the power input and this is really the power output okay of the system.

And the way that the actuator drives the mechanism you know is based on a sensory aspect which comes from a sensing tool a small sensing tool which we will see how much motion or how much mechanical you know output is being delivered and if there is a path correction which is needed path correction will be done in accordance okay. And that happens through electronic device which will again be able to guide the actuator by giving definite power outputs.

So, that the mechanical system can execute a motion or the mechanism can execute the motion or maybe some mechanical delivery of power okay in whatever formulation whatever form in a certain specified manner okay. So, that manner base the guidance is what the job of a mechatronics system is really about.

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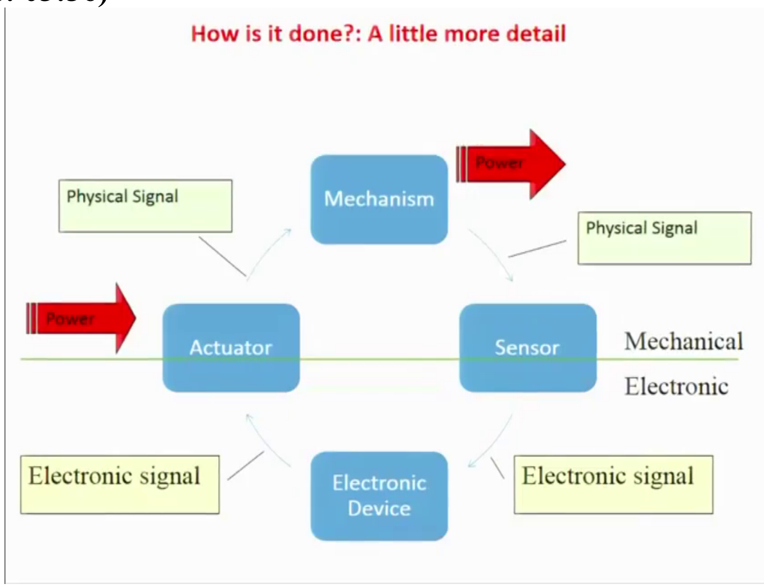

So, let me look at the details of it so you have an actuator which is powered from an external source okay and it generates a physical signal and this physical signal is able to drive a mechanism which will give out of the power of the system okay. So, on one hand you have the mechanism which is giving out power delivering power in some sort mechanical power mostly okay. In and then on the other hand you have the actuator which is doing this job of delivering power inside so that the mechanism can deliver power outside.

For example let us say when we talk about an engine and a wheel okay so the engine is giving a power to gear train and the gear train is able to drive by making rotation happen through with the wheel and the rotation is getting translated into a linear motion okay. So, you basically driving the wheel of a car through this whole process of actuation and mechanism okay. But the important part that how well the mechanism behaves also describes of how well the car runs okay.

So, in that even if power is available only at a constant manner you may not be able to have intelligence guidance it is a guidance possible unless and until you basically take the physical signal okay in form of a sensor etc to see what is going on in terms of the operation of the power delivery of the mechanism. And then feedback with an intelligent electronic device the amount of power that would be necessary from as a function of time of this actuator through an electronic signal okay.

So, that it can actually be able to guide the mechanism to a intended set of to do an intended set of operation in an intentional manner. So, all this intent to based control is what mechatronics is about.

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So, the first part so there are many parts of this mechatronic mechatronics based control so one of the important parts is the cam CAD and the CAE computer-aided engineering part of the mechatronics system so these are systems which are essential to realize or drive some of the mechatronic based intelligent systems okay so this is one of the first steps of intelligent systems I would say. So, how are these related how is computer-aided engineering and design and manufacturing related together.

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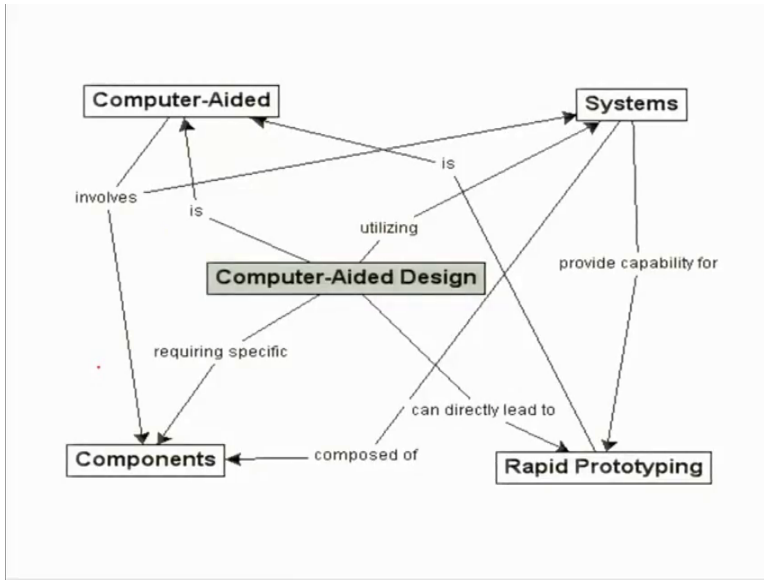

So, this is being shown here in this network so you have one manufacturing tool the rapid prototyping tool you know which is based on computer aided design. So, you have a CAD package and this CAD leads to some data you have actually done this learn this towards the beginning of this course. And it is basically fed into a rapid prototyping tool okay to make a part or realize a part so from the design to the reality you are able to have intelligent computer control okay.

And then we talk about a management system you know a component management system which basically looks at the system level what are the components which are needed and how these components can be formulated. And so there is an interaction between the computer-aided designing and the component and the component management systems okay. And there is an integration of computer-aided you know involvement of both the computer-aided engineering phase involvement of both the computer the components as well as the system level information.

You managing the computer-aided engineering information through the computer-aided design you are basically feeding information from the computer a designing into the CAE okay. And on the other hand also using CAE to do the computer aided manufacturing okay. So, the systems are providing capability for rapid prototyping. Similarly the components are providing capability for rapid prototyping again the data that is needed for actually synthesizing what we have to synthesize comes out of the computer aided designing and everything is managed by this comparative engineering tools. So, this is how the integration of all the three work out to be.

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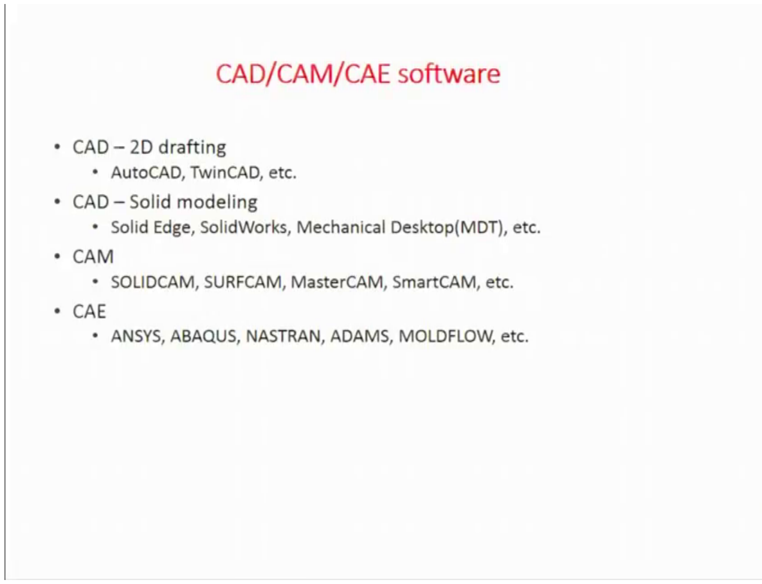

There are different software's which we do this job for example compared to designing software for example AutoCAD or TwinCAD would do the job of how a design can be manipulated manual word you know stored in form of data, coordinate data again many sections can be seen or how they can be put together as assembly. And then a functionality part of the head comes from the CAE which talks about how you can assemble them together how you can put them together in space you know what's the component so basic component level information's have been created.

So, the various packages like answers ABACUS, NASTRAN, MOLE FLOW etc determine that part. And then we talk about you know CAD has obviously 2D drafting as well as solid modeling and I think we have done a lot of this towards the beginning of this course when we talked about CAD as such. And so in order to integrate them in order to make this CAE happen you know where there is functionality a part based functionality as in a linkage or mechanism or an assembly being realized.

You need this manufacturing part which is through Solid Cam or Surf Cam or Master Cam these are some of the software's which would do this job. So, in other words we are having a computer I mean computer-based assistance and intelligence assistance for realizing a geometry from numbers to physical world okay through all these different things.

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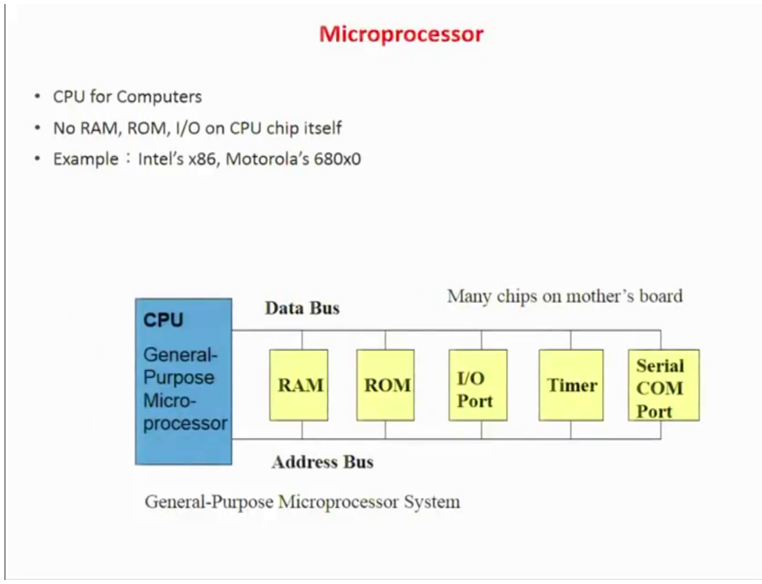

And the other thing so the other thing we need to learn is well microprocessors and microcontrollers and what are the different what are the differences between both because they are both going to make products systems there are intermediate systems with electronic control. So, microprocessors again comprised of various different things connected together on a board okay. So, for example there is a CPU which does processing there is no ROM or RAM are you on the chip itself.

But there between units so there is an any random access memory there is a read on the memory there is a input/output you know device again but they are all on different that of different entities connected together and you need to necessarily go to connect to all this together if we talk about a microprocessor examples could be Intel's x86 or Motorola's 680 X0 these are 2 micro processors for example. So, you have connects between the CPU the RAM ROM IO ports primer, serial com port somewhere maybe on a motherboard.

So, there are many chips from the same mother board ok and these are connected together through information sharing mechanisms the buses ok which are in short form of the legend of the mass which is actually which means that they have systems to handle data. So, you have input output data okay being handled and they are all connected together to formulate a general-purpose microprocessor system.

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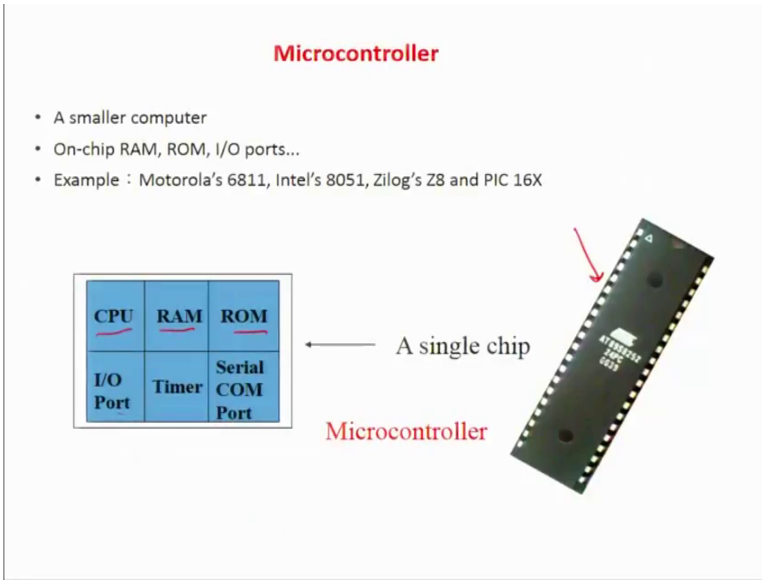

On the other hand if I use the microcontroller the basic differences so it is a smaller computer ok and it has everything on a single chip. So, you have on chip RAM, ROM I/O ports based on a single chip here. Let us say for example this is a micro controller chip which has everything in it so CPU, RAM, ROM they are connected together through various systems, subsystems but then you know this is one entity rather than a board assembled with many components together okay which is formulating microcontroller.

So, you have again Motorola's 6811 or Intel's 8051, Zilog's Z8 or PIC 16x these are all different microcontrollers.

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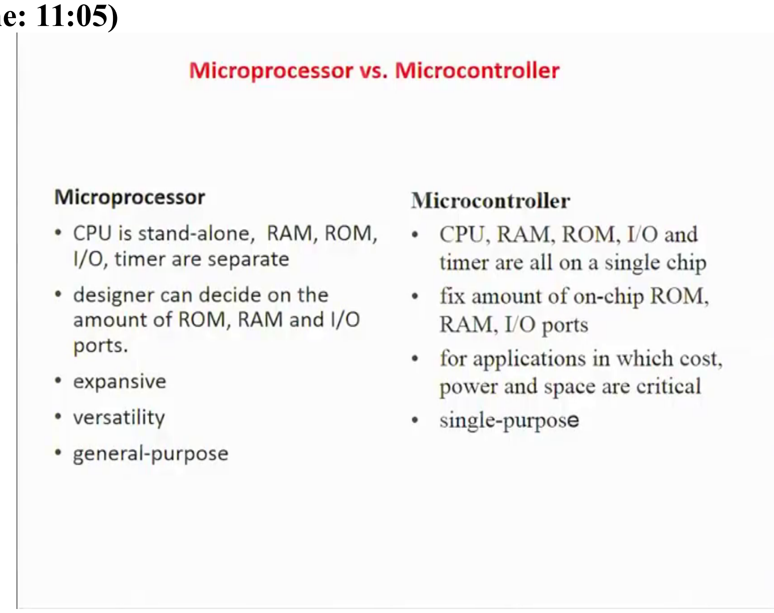

So, essential difference between both is that in a microprocessor the CPU standalone, RAM, ROM, I/O and timers are separate and a design like I decide on the amount of ROM, RAM that is needed or even how many I/O ports are needed they are expensive in nature very versatile general-purpose however microcontrollers I what we appended they have is they are smaller and more integrated so everything is together on a single chip okay CPU RAM ROM and I/O and timer are all on the single chip.

You have a fixed amount of one chip ROM okay RAM or I/O ports for applications in which cost, power and space are critical. Microcontroller boots on is a better tool rather than a microprocessor because here we have to assemble the board on board okay something. So, and then the microcontroller is only with a single purpose. So, it is programmed in the manner that they deliver on the certain job.

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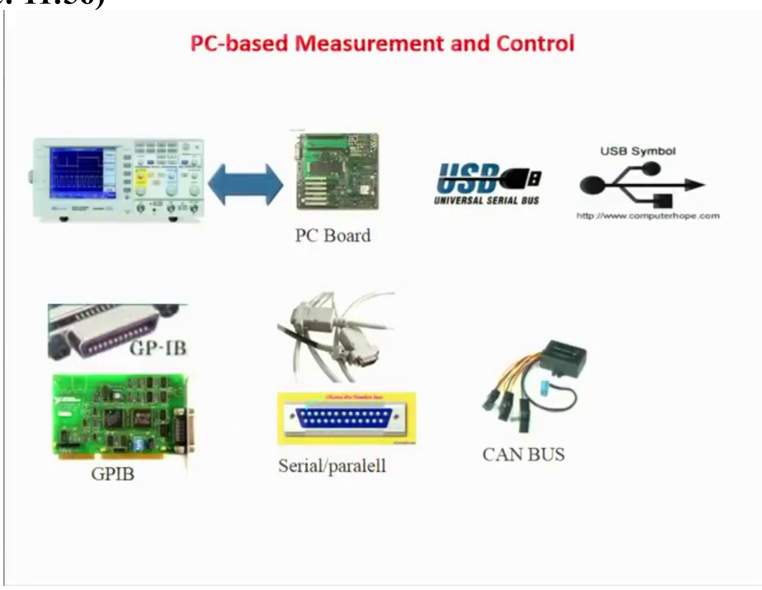

So, let us look at again something that is very important to understand what talks about PC base measurements and controls. So, typically there is a PC board okay and you know it will acquire signals and it will try to help to plot the signals. This is probably an analog of course here will do that it would actually measure you know signals which are they are different. So, if this is the cathode ray oscilloscope for example okay.

So, how the data is handled is by many means for example you can have universal serial bus USB based ports you can have serial parallel ports you could have campus input of GPIB. So, all these different you know input/output ports are utilized to talk to the controller okay which is assembled in the PC board and use the various aspects of the controller when we talk about design PC based microcontroller okay or microprocessor.

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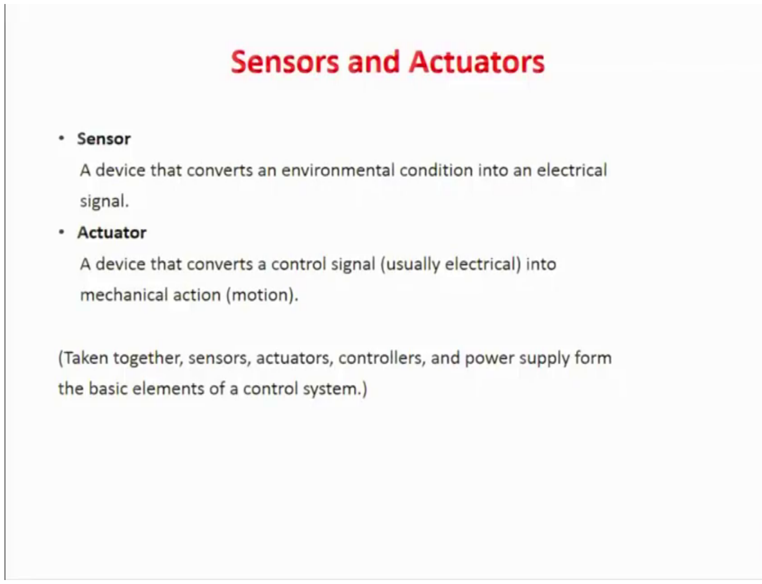

So, the whole idea here is that whatever sensors and actuators are integrated to an intelligent mechanism or mechanical system has to essentially use some of these ideas together in order to function in a unified manner. And let us look at sensors and actuators I think I have vastly described this in the memory earlier. But a sensor is a device that converts an environment condition into an electrical signal condition could be related to motion or related to you know surrounding atmosphere with a certain dangerous gas ok.

Something which creates a change okay and then we are trying to transfuse that into a signal which is more machine readable and then actual on the other hand is a device that would control signal it will be electrical in nature into a mechanical action that is motion it could be a motor rotating for example which we had probably rotary action to I mean linkage or a mechanism we could transfer this action further into something maybe a linear motion or maybe a periodic motion.

So, take it together the sensors actuators controllers and power supply form the basic element of any control system in it.

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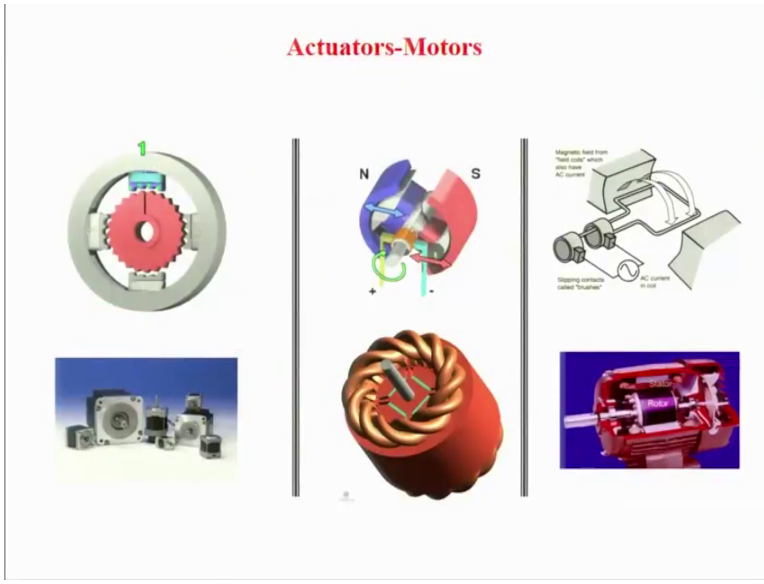

If you look at discretely what these actuators would do these are for example some of the actuators this is a motor where essentially what is happening is that the magnetic field is being varied between different places from 1 2 3 or 4 ok. So, there is a rotating magnetic field of the stator which makes the rotor move which gives you rotar power out of the system these are some of the systems ok and eventually.

Again there can be a DC signal given to the central shaft okay and the stator which is more fixed in nature with northern South Pole which could cause again circular motion to happen. There could be a AC may signal due to a magnetic coil which is there in the fixed magnetic field and you know the AC signal would ensure that the current directions alters because of which there are differential law enforcement forces on both these components based on whatever is the static field okay and it will allow what is to rotate or the contacts in such cases through these contact brushes which formulate the basis of feeding the files which are there in the rotor.

So, these are some of the you know actuator which are which would be conventionally huge to create motion.

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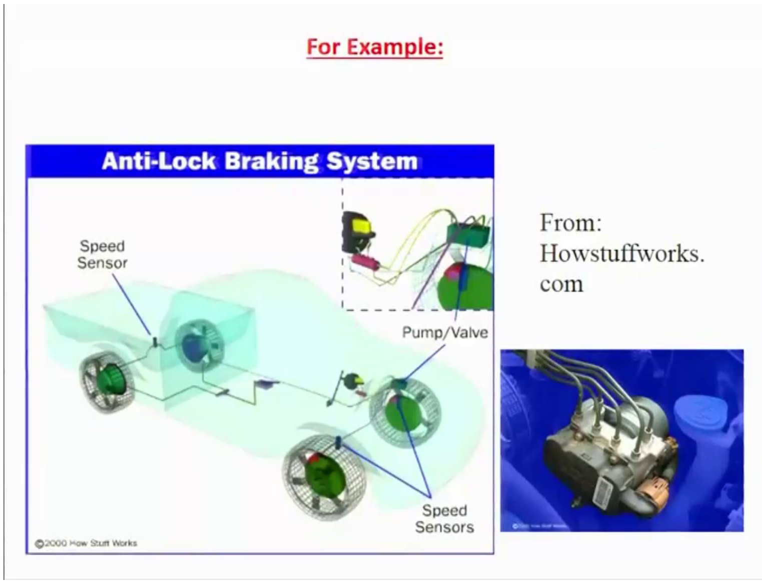

For example if you look at anti-lock braking system in a car so the system basically has a mechanical component which is being pressurized through oil pressure which is controlled through a set of pumps and valves. Pumps are again controlled through motors ok the idea here is that the distribution of the braking force has been you know monitored and accordingly switch braking is provided mechanically to the four different wheels both front and back.

And in this case so there are various speed sensors for example which will moniter differential speed on the wheels okay and accordingly decide what kind of braking forces through the electronic control.

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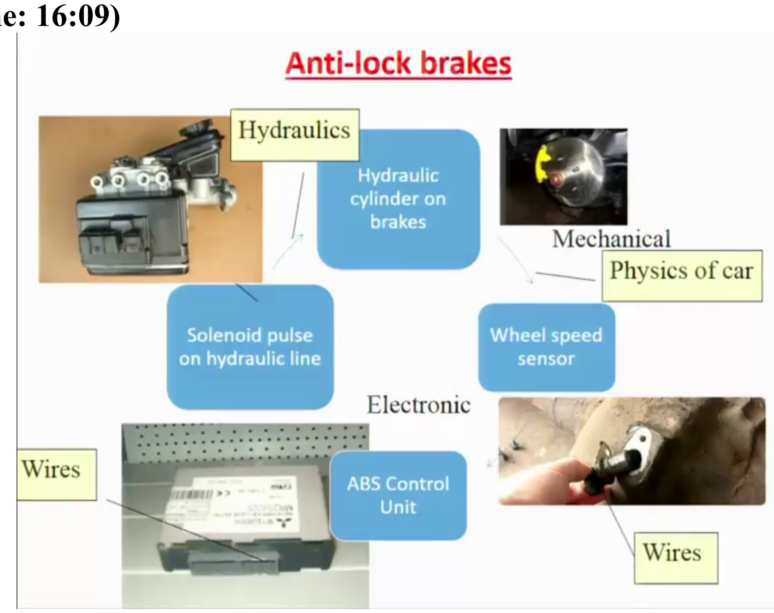

If we looked at what are the different parts or to treat it with different systems which can control this you know differential braking mechanism. So, you have hydraulic assisted braking which is actually through hydraulic cylinder on brakes which you can find here right here okay. There is a mechanical aspect which is about how much braking force would be needed. So, the hydraulic cylinders will provide just about enough forces and that would depend on the pumps and motors which would allow the oil okay to go inside and create piston pressure which will cause that this brakes to happen.

There is of course a wheel speed sensor which is there, which is based on some mechanism again you know for sensing where mechanical motion is transfused back into electrical signal and there is this ABS control unit which will determine how much of pressure goes to whatever wheels you know in terms of pumps getting 4 different routes or for different oil routes to send to the different cylinders okay which will create the pressurization action at the mechanical level or wheel level.

So, it is a combination of the hydraulic cylinders which will create some kind of mechanical output the wheel speed sensor which will monitor the output, feedback to the ABS controls which will again create the solenoid pulse from the hydraulic line you know whether it is the left front wheel of the right front wheel or similarly the rear wheels and then how much amount of all it should go or it distributed into these four brakes so that exactly required power braking this given differentially in both the different wheels.

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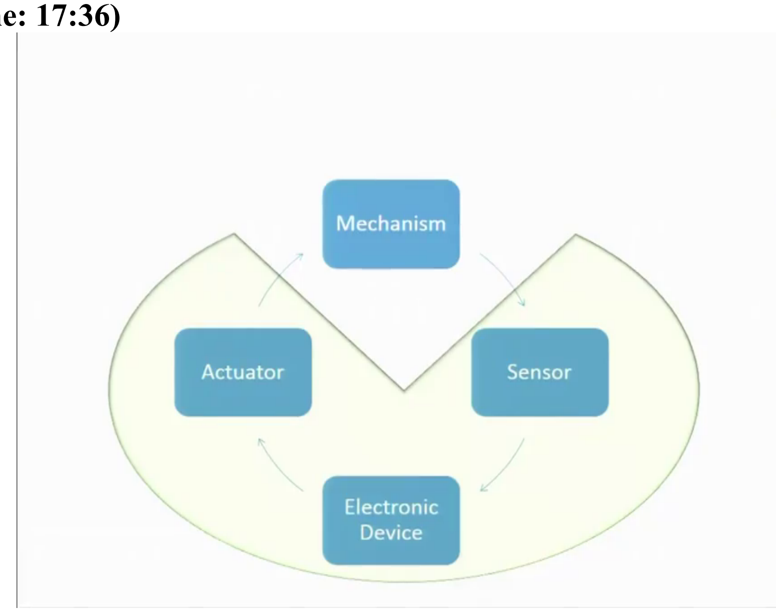

So, you have one began to the new sensor, you have electronic device and actually all in place when we talk about the rotary system there are many other examples.

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For example mechatronics can be used from macro to micro applications the figures here on the right show big objects cars, stealth bombers, high speed trains which have based on some of these metaphoric principles okay again you can have micro tools or consumer electronic products or MEMS which you have extensively done earlier which would actually be direct application of such mechatronic systems.

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Manufacturing has a lot of application demanded too many mechatronics for example all the CNC machining processes where I explained to you there is a stepper motor a DC motor and there is a control intelligent control based on you know a machine controller or machine CPU is all based again on mechanic mechatronics. But there are sensors which would be using you the speed governors or which we also used to see what is the depth and speed the motion of the radius racks okay which are able to align re-align the workpiece with respect to the working tools.

So, these are again very high end applications of mechatronics then I advantages then you got the highest accuracy and precision and be able to create complex shapes needless to mention all this because I have done it extensively why doing CNC programming.

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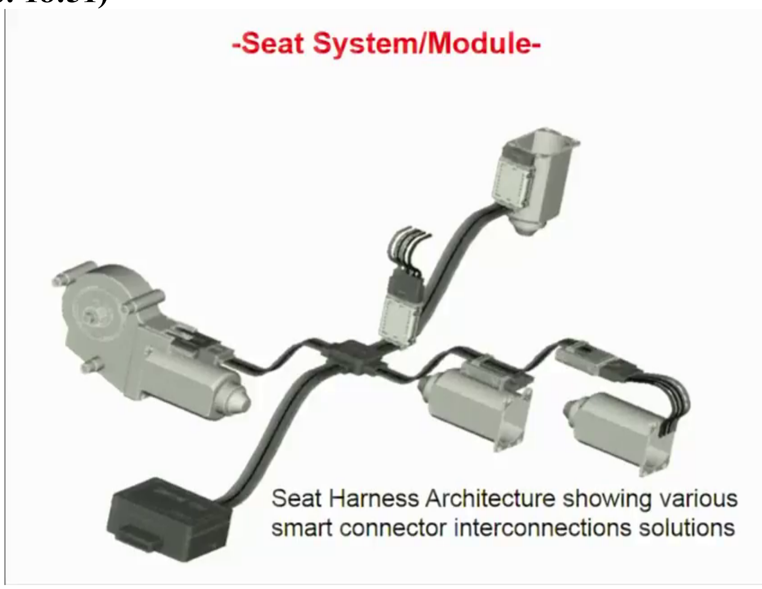

This again is a mechatronics system for the seat module you how much reclining has to happen from the how much seat-forward or seat backward has to happen based on the percentage size in the car is a very important question. So, you again comprise electronic management system which would actually automatically as the passenger comes in there are certain cars where the seat would automatically managed or even at the press of a button it will manage.

So, that there is an requisite ergonomics position for a driver of car which comes into play so, as a matter fact any other vehicle. So, you have a seat architectural hardness showing various smart connectors interconnectors together which would provide a solution for in his seating system which is also mechatronics experiment.

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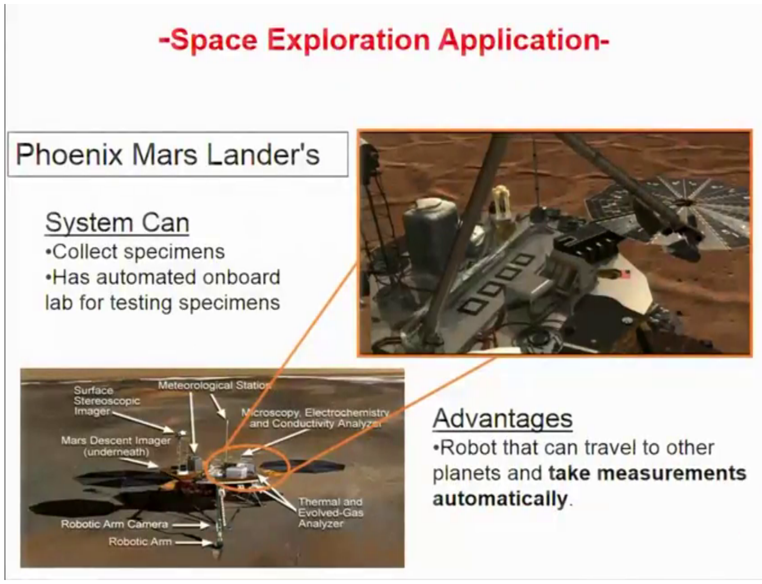

Again what can be done in space this right here is a Phoenix Mars Lander it is a pod which can collect specimens you know through electro microscopy electro chemistry various different analysis on the same pod. So, it is extremely complicated again mechatronics system mechatronic assisted system which we take a sample analyzed the sample send the data. Do all this intelligently while moving itself through a very complex terrain ok.

So, the advantage is this robot has it can travel to other planets take measurements automatically and send and signal those measurements back to the ground station for us to be able to look at different aspects of planets and others you know interplanetary space. So, this is the range and expanse of mechatronic systems. I think I would like to sort of introduce and close you know this particular module.

But in the next few modules there will be a lab activity driven by you know again the teaching assistant for this particular course Mr. Sanjay Kumar who will talk a little more about various aspects individual aspects like sensors and transducers and how they work and it will show you in the field by being able to set up data envision environment based environment for different thermal controls which would be performed on the chip level. So, with this end these particular lecture thank you see you and goodbye. Thanks.