**Electronics Equipment Integration and Prototype Building**
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Lecture – 01
Introduction to electronics products

This particular lecture series is about how to make a small electronic equipment prototype in a small setting like your college, your work spot or even at home or in case you are a school student or just a curious person in the small workshop or normal places which you have access. Thing is all formal prototype making involves 2 different activities; one of the first activity is how to conceptualize a product saying what is the product, how is it used and what they will do with it and so on and what exactly the product is supposed to perform ok. Now, kindly look at my presentation.

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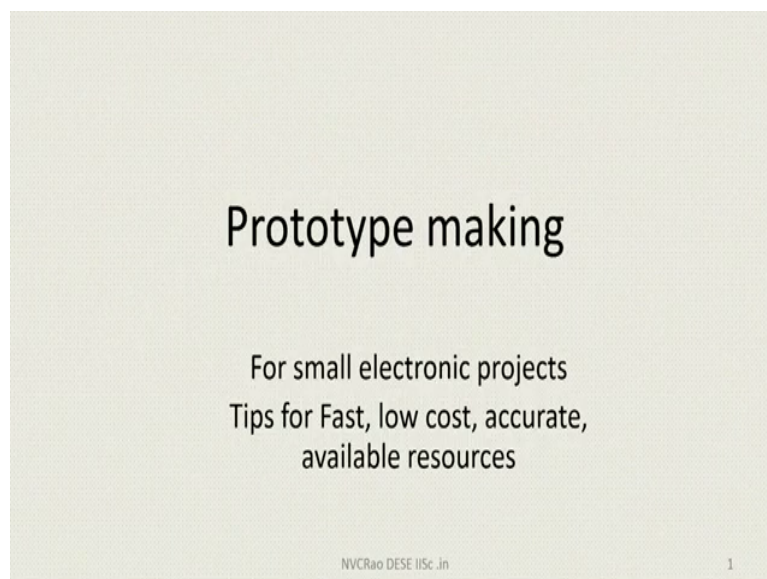
So, the small presentation is all about how to make for a small electronic project how to make fast, low cost, accurate prototypes using available resources.

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So, next slide is going to show you why do we need to have a prototype at all. To start with an electronic schematic is converted to a printed wiring board; contrary to normal usage the word printed wiring board is more generic. So, even if you had to take a small item like what you call remote control or an item like a small power supply all of them consist of small electronic components all put on a schematic arranged as for a schematic and some logical way depending on a circle diagram this schematic shows how these things have to be interconnected.

So, when you interconnect them one of the simple thing is for example, if you have a resistor; obviously, you have 2 lids and you have an active device like a transistor you have 3 lids. So,

the thing shows you about how to connect a transistor that is what this schematic diagram is about. Now the thing is in reality it is slightly different.

So, I will just try to show here, you see here I have here what pardon me for my ignorance what looks like a transistor I hope it is a transistor, as a something there is a circle and something then you have a positive rail then you have another rail and then you have a gate here.

As if things are not enough usually know you will have some resistors and here you can probably have a load and you can have something and all that like this now everything is this whole thing is analyzed each value of each of these things is determined usually by a some sort of a circuit analysis. So, I am just removing it to avoid the clutter here.

So, as electronics engineers I am sure you will know about a lot about this thing what is a circuit diagram and then what is a schematic. And at some level probably this is already given out by the manufacturer is it from a textbook or it is from an earlier report or you have tried it yourself and for every device or directly on the internet you have a lot of researches are available on how to connect the schematics together.

Now, comes the important thing, why we need a prototype. Obviously, everything here the full thing cannot be put onto one PCB, if you put it in one I am sorry one printed wiring board there are certain advantages, there are several disadvantages. One of the thing is simple repair is not possible and not easy to put together a simple prototype.

For example, let us say you would like to make a device which already uses a USB power input, typically all USBs are about 5 or 5 volts and if it is connected along to a normal PC or anything around 350 to 400 milliamps can be taken.

However, if you take the connector which is called you know micro USB type C or anything connector itself is capable of taking shocking amount of power several of them are capable very much of taking 10 amps into 5 volts 50 volts but for a extremely short duration.

Now comes that thing so, what will you do with the power supply, do you now take it out of the that unit you want to do or you would like to incorporate it into the unit itself or let us to fashion is try to use a battery charge a battery and battery can be a single cell or battery can be multiple cells. So, by default with this usual lithium ion, lithium ion lithium polymer, nickel metal, hydride most of them already come with 3.7 volts which has become a standard.

So, everything finally, needs to be split into sub assemblies. Having done this the basic working circuit is ready for us, but unfortunately real life is that that so called power supply is telling you the clips are required, then a little while back I mentioned to you that a connector is required, connector can be anything in the case of a mobile you have something that 3.5 mm audio connector.

So, 3.5 audio connector is just a an opening their original ones just had 2 contacts inside and later on things started having 3 contacts by which you could have stereo, then later on it became 4 contacts by which an extra contact was used also as part of the microphone. Now you have see here we have this connectors which play an important role, now we have several decisions to be taken saying this is connected go on the external case or does it go as part of the printed wiring board.
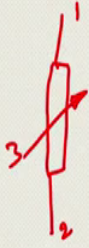
So, even today both options are available all option that is you can even mount them on the printed wiring board or alternately can put to them the case, that is where to take a decision you just need to put everything together at least the first time.

Now, there are other hardware other than these connectors and all we have control elements which are typically switches.

Control elements can be key, key means you know something you press, switches usually a toggling device, then you have potentiometers, then you have rotary small rotary knobs and all that. All there is suddenly you will see that what was a simple extremely simple, this is a very passive resistor. Suddenly this passive resistor we end up with the funny thing, one more (Refer Time: 08:57), it has become a potentiometer. So, what was having actually only 2 leads now it ends up with the third lid. So, we end up with all these things you now saying potentiometers and then it is now sort of compulsory that you no longer use this type of devices anymore, why do we do not use it is that lids to a lot of unreliability and noise.

So, this so, called potentiometer is probably replaced by an electronic voltage controlled some device which has probably case a single key or 2 keys and so on, same thing with a rotary devices saying, do you have something which you need to rotate. Why do you need rotation, something has to be increased, decreased, something has to be a potentiometer can be linear

meaning going in a straight line, a rotary device something needs to be always circular like this, while these are all come under the category of control elements.

We now have several display elements which is part of electronics, pardon may for repeating what look like very elementary simple things, but then the way we treat them it needs to be told again like that most common is dot matrix array a typical output, we will probably have an LCD screen and the simple simplest LCD screen we can have as a dot matrix array meaning already there is a predefined characters and each character is made of certain dots some of them are earliest we had 7 segment displays.

Now, we have 8 into what we call 15 18 to 16 all sorts of small characters all come in rows. So, you have a 20 character display, 40 character display and so on and the moment you have this dot matrix display you come into the thing is difference between all these things are I think like a dot matrix array or anything else will probably need a transparent window through which you can locate it. And the moment there is a window, now suddenly they everything inside is now transferred to the outside how do we treat that window.

Do we need to provide a bezel all around, do you need to put a mask or what is it you do there and we also come with status indicators and warning lights. I think why the English language itself you will know a status indicator shows something is on or off or the status of the thing, another say warning saying you are running out of power.

So, these things in variable you know form very useful element in the product like you have this what you call control elements and then you have display elements and slightly different thing is there is another class of things which can be put here or the new type of electromechanical devices like buzzers and vibrators. Buzzer is a something which buzzes and you can hear the sound, vibrator is something usually a small motor fitted to a unbalanced weight which will make things vibrate.

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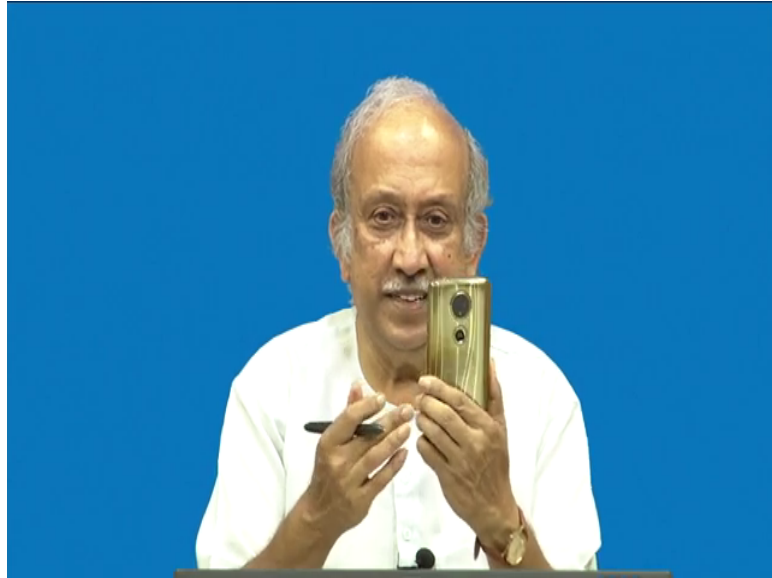
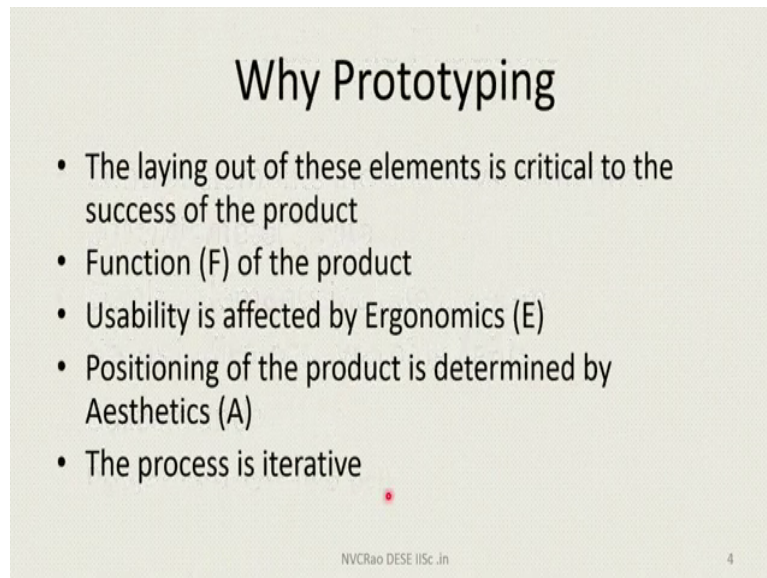So, most of your things like this mobiles also come with the vibrator inside.
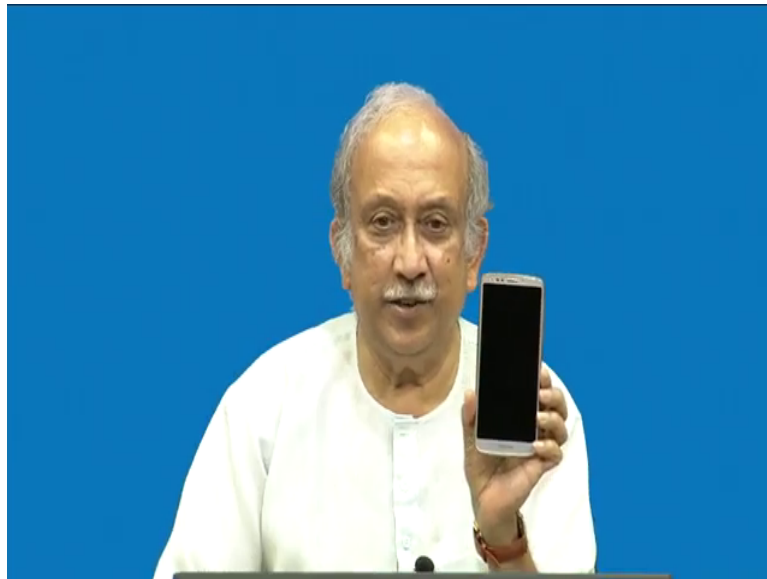
And turning it the other way suddenly you will notice now what I talked to you about all along probably is not relevant anymore because we have a large display, but running this display and maintaining good things are super flow so, you do not need it. Best example I can give you is the small Wi-Fi router or switch that you find in your desktop or away from there, it is a small box you do not need anything all it requires is a few warning lights, status indicator, status indicator indicates whether status indicator indicates whether the power is on or not and a warning light can be indicates saying it is out of sync or some other problem is there and it also indicates whether everything is normal or not.

So, in a unit like that every time, we need not be forced to give it a big display like that and last thing we end up with small cells which are both a bone and a curse. The bone is you can always replace the cell and you are back and you need not worry anything the power is a

portable power source which is already available for you. So, these are very much part of any equipment.

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Now, welcome to the next slide saying why do we need prototyping that much everybody knows what I have shown you everybody knows about it saying these are all the elements. The laying out of these elements is critical to the success of the product, what started as a simple project of assembling everything together and demonstrating or we our self checking what it is going to be we will now suddenly it needs to become a product.

So, we do have work to do main thing is every product has a function to perform, a little while ago I talked to you about the almost black box that is the Wi-Fi router. Obviously, Wi-Fi router 2 things it has to do, one of the first thing is that somehow connected itself to the internet out to the somewhere and secondly, it has to transform all that signals and all to

something which we can use all the time. You have seen that no that is the basic function of the product I have taken a router because you are all very familiar with it. Next if you tack a slightly improved one is probably the remote control which I use for your TV, which is quite common.

Then we know that the function is very what looks obvious sometimes it is not necessarily obvious, I am sure you would have felt very frustrated first time you get another remote saying already have enough remotes around the house. We have one for the TV, one for the set top box, we also have something else for the audio in case you have a audio device hanging around and you also have something where the climate control and so on. Plus if you are one of the early adopters we have already ended up having remote controls for all the lights fans and all that. So, the generically all of them come under this thing the function is defined separately.

Next important thing is how usable is the product you would have felt quite often frustrated when you look at any product no you really do not know which button to press and our friend Murphy is looking at on whatever you press everything reset or you will lose the connection. So, this ergonomic consideration saying how do we ergonomically make things hold.

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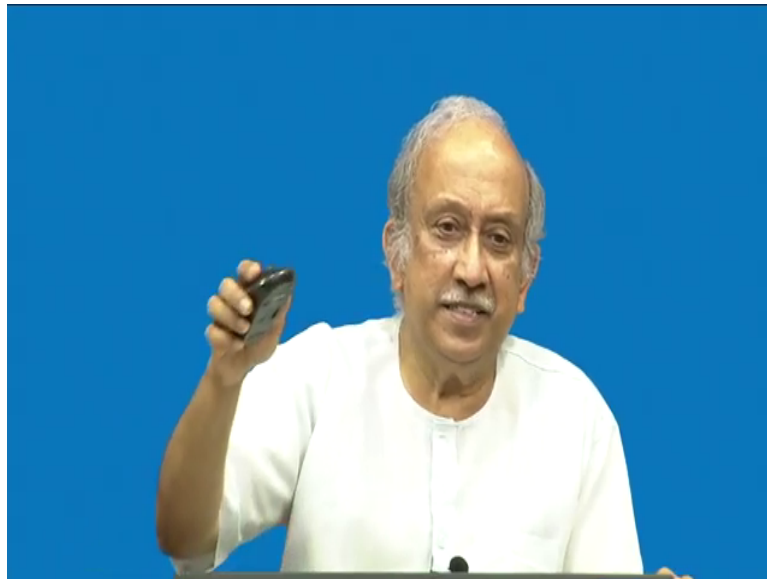
Best ergonomic is this mouse is a very peculiarly headless tail less device and continue to be called a mouse and you see this everything depends on the position of these things, how value grasp it, how value hold things and then you have several wheels and all that. So, gamer people young and old all of them know you probably need one or more extra switches. In contrast the other what you call apple never believed in having too much of it saying one big you add of thing you press and it should work not even split it, which I think is genius. Ergonomics will tell you how convenient it is for you to operate things and another thing is we have population stereotypes which we learn all the time.

Population stereotype is something to open, something to close, what is left and what is right, how do you drag things and when you move something up, if when you move the knob up, something tends to go up, when the pointer go up or the screen roll. This is where the ergonomic considerations are very critical to a product saying, one is population stereotype

then what about the young people young people have changed everything. So, we can talk about just like the ergonomics.

Next we come to positioning of the product determined by the aesthetic considerations, in the core most products are probably at one level about the same you understood no at one level the basic technology is same and all then here positioning refers to product positioning from the marketing point of view. So, just know I gave an example of a game PC, that is also a PC and then we are all familiar with you know high power low power in these things and if you see the inside of most kiosks and consults.

Basically they also have a simple display and a keyboard or anything, but it runs in a different way it you know starts up by itself and runs like that so, this positioning is very critical. Now comes the important thing this prototyping layout and achieving what is called the aesthetics ergonomics functionality A E of ratio is iterative, that is why we need to make products.

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Now, comes the very critical thing, saying where do we start, in my case I am using directly material from.
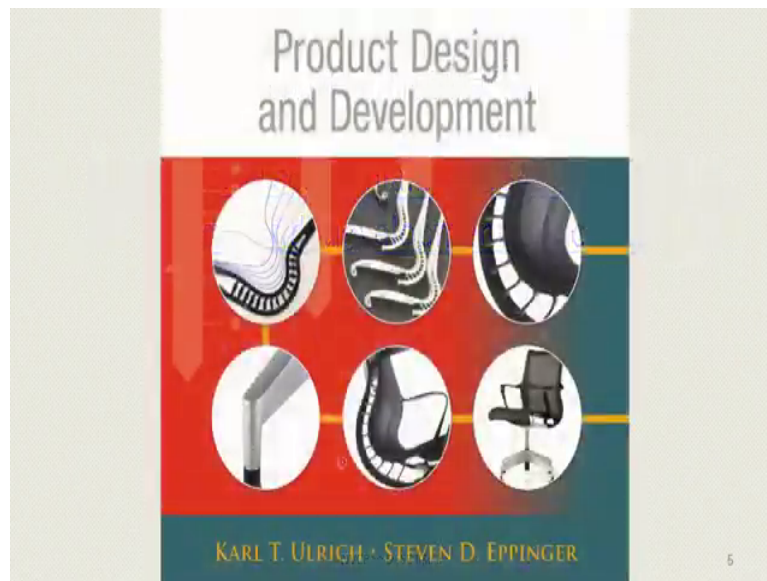
These professors Ulrich and Eppinger this whole thing started from MIT Sloan and this book is available for you I suggest as part of the IP or anything, just to go and lay your hands on it. If you can get it in your library it is fine alternately it is available online for a medic any series is fine, you understand no in edition is not important. Because what is inside is very important it is a very comprehensive big book ok.

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This many things are there you see here right from all the way from introduction everything it goes here like this, but what we are interested is only this prototyping at this point you understand no, because you will soon learn that the same prototyping is used for manufacturing consideration. It is also used for product architecture and industrial design, industrial design makes products humanly usable.

Best example given by industrial design is if you see any of the machine shop machines, it is practically impossible they control elements are very you know put. So, far away it may lid to accidents and let access the environment and something is all about robust design and economics of this things and all that.

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is the CIBC Professor and Vice Dean of Innovation at the Wharton School at the University of Pennsylvania and is also Professor of Mechanical Engineering. He received the S.B., S.M., and Sc.D. degrees in Mechanical Engineering from MIT. Professor Ulrich has led the development efforts for many products, including medical devices and sporting goods, and is the founder of several technology-based companies. As a result of this work, he has received more than 20 patents. His current research concerns technological innovation, product design, and environmental issues.

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is the General Motors LGO Professor of Management Science and Innovation at the Massachusetts Institute of Technology Sloan School of Management and is also Professor of Engineering Systems at MIT. He received the S.B., S.M., and Sc.D. degrees in Mechanical Engineering from MIT and served as Deputy Dean of the MIT Sloan School for five years. He specializes in the management of complex product development processes and has worked extensively with the automobile, electronics, aerospace, medical devices, and capital equipment industries. His current research is aimed at the creation of improved product development practices and project management techniques.

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Coming back to this people read a little about it, he is a basically mechanical engineer from MIT, same thing with Eppinger professor of engineering systems at MIT and they put together have put out this books there Indian version is available, similarly there are other versions and then it is self explanatory what you see here I will now skip to the a little bit of the actual things. You have seen here in all this every place you know you probably need to have a prototype, what looks very simple saying identifying customer needs not that easy not at all easy.

So, several of us know that they have a clothes washer at home fine, but there are too many buttons to press, then similarly we have a dishwasher little tough, other extreme I will say take the case of the microwave oven in spite of all the options are everything no everybody
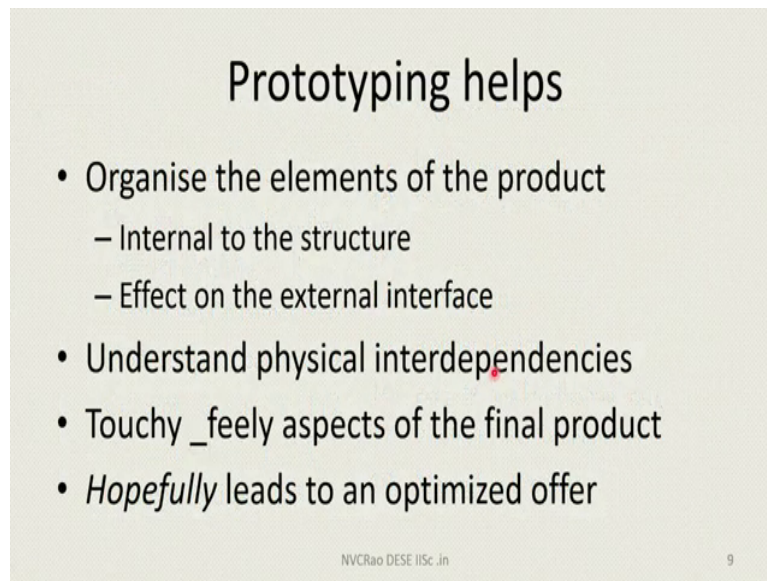
knows open the oven put it press some button it starts rotating and we know it is working you understand no.

So, usability is very easy in those considerations there are things like a microwave small microwave can use for reheating bigger way microwave does something a very big microwave usually forty fifty liters thing can almost replace a regular cooking range. Now this is where what does the customer want is a big thing, right now last about maybe 10 15 years all fitted kitchens are so, called dream kitchens, have a microwave just above the cooking range you understand no cooking range you have all the hobs or burners or anything you have the microwave just above it looked ridiculous is it, not dangerous. And the microwave suddenly does something else you know what it does? It is also the kitchen hood it extracts all the air about takes it up and moves it out I never thought it is possible I never thought anybody will buy it.

But now I see that several places where you go you have this hob under the hob you have the regular oven in which you bake you braise various things above that at a reasonable height you have the microwave oven we can open and put things and the bottom of the microwave oven also serves as the hood which takes out all the air that is exactly what the customer wants and people have been buying it. If you see it once no you will probably want to buy one immediately probably for yourself the others.

Now coming back to my slide here comes everything like this know why all this product design and stuff is required is one is, how to arrange things together, how to make it humanly useful, how to manufacture it all this depending on customer needs and somebody has to write this finally, intellectual property which you can hold on to this. So, in all these aspects you must make a prototype.

So, a prototype helps to organize the elements of the product internal to the structure, effect on the external interface. So, coming back to the if you see my mobile, why I am showing these we all know about it. We all know that probably it make sense to keep the 3.5 mm jack there because you can carry it here and make it and all that, you will be surprised now some of the current new mobiles do not have a jack anymore, everything has gone Bluetooth wireless and I do not even know it is Bluetooth there not it is at least wireless. So, redundant here and we all know that probably we need this charging port here. Now is it logical to keep the charging port here or is it somewhere else, is it probably logical to keep it here or best is wireless charging again you understand know.

We have full wireless charging so, they are very good mobiles which do not have any of these openings except by default have a small speaker there and in this case we also have a small front camera. A mobile communicator is suddenly a camera and then nobody carries out those

toy cameras in their pocket anymore because it looks like there is enough processing in this what you call octa core processor and you do not need to carry another small this thing and you end up with something here at the back.

That is the once again a camera or dual cameras and probably a small flash something which does ranging in fingerprint sensor and people have tried to remove the fingerprint sensor from there saying why do not you make it as a capacitive touch and some are now available without any of these things because it is face recognition automatically.

 So, maybe it says you are too old to operate it so sorry all features will be disabled for you except for dialing large numbers everything will be disabled for you and if you are small child know it says which game they want to play intelligence is built into it. So, coming back to my presentation here, we have the effect of all these elements on the external interface and the reverse also.

The external interface determines the internal layout and structures while visible elements have spoken to a bird a modern new mobile may have a minimum of 5 to 6 antennas to carry out their functions. So, these antennas also have this physical interdependencies one of the other should not indicate with the I mean interfere with other and finally, how does the mobile feel touchy feely.

If we can make a prototype it is very much possible hopefully this lids to an optimized offer. So, this whole lecture was only about how to why a prototype is required. Now comes the important thing which for this session I will I will try to carry on to the thing.

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A proper prototype is of course, very expensive, you understand the fully functional evaluative prototype is really expensive and contrary to the stories you hear 3 D printing is not easily within reach, you can buy up 3 D printer do something, but you cannot really a do anything with it, somebody has to critically do the part design and the manufacturing other person has to wet your design and still for the first timer is still a trial and error, not really needed for a flat geometry. So, if you want to make a something which is typically a cuboid or a parallel prepared which has 6 faces, not that easy to make these things.

Similar way everybody tells you now if you can imagine a product and design a product easily we can make it by computerized machining because also not true. This numerical control machines themselves you know are still nothing same thing is with laser cutting also. So,

right now I will that seems to be a logical end to this place here I will stop here I will repeat the same slide next time and I will continue from there.

So, thank you allow me to repeat once again that you kindly look for this what you call this book product design and development it is available in regular book shops you can get it, you can get it online most likely your library will have it, do not think this is the only book several of the other books also cover these things and if you are one of the people who are now in the modern economy and modern engineering schools.

The whole thing about prototyping how to come out with alternate solutions, how to choose the solutions, how to evaluate and based on that know which are the ones which you need to go for manufacture is for already explained to you.

This lecture is going to be only about lecture series how you can make it without having to seek help outside meaning with whatever researcher you have it we can still make it is exactly how we were making things 40 years back, in 75 - 76 and we started we are making everything with available materials in a small way. Once you are a little confident that your technology can be demonstrated and there is a place for a product like this with certain features next you can go and for making a really formal prototype. So, thank you we will meet again.

Thank you.