Engineering Graphics and Design
Professor. Sunil R. Kale and Naresh V Datla
Department of Mechanical Engineering
Indian Institute of Technology, Delhi
Lecture No. 03
Introduction (Examples of Visualization -2)

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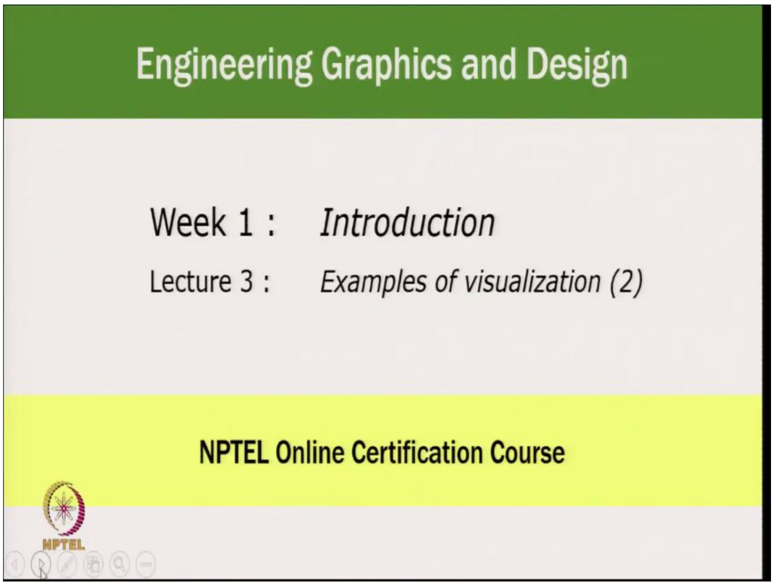

Welcome to this course on engineering, graphics and design. This is the third lecture of the first week, and in this lecture, we will continue where we left off in the previous one, and continue looking at examples of visualization and see how pictorial representation manifests itself.

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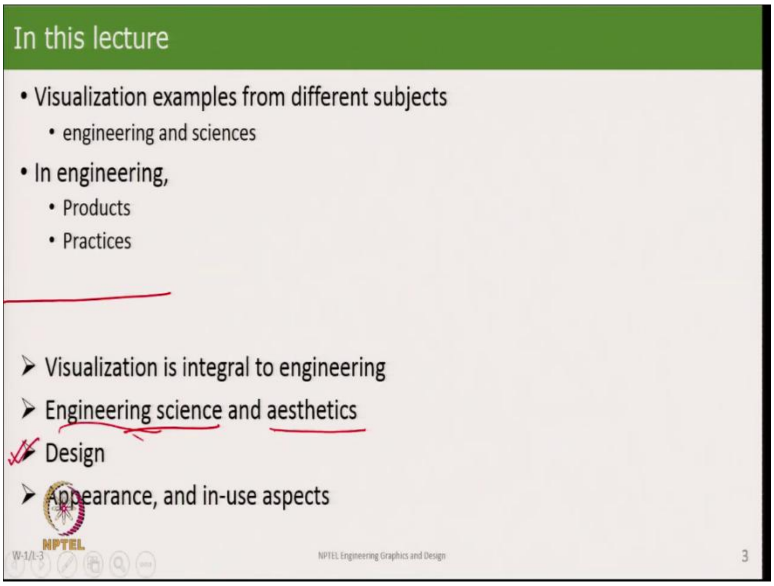

So, we will take more examples from different subjects in applications. Engineering and sciences, and even outside of engineering or science. And we will look at products and practices.

To recap, what we had said earlier, visualization is integral to engineering. Thinking of an object as a picture, representing it in a paper, pen or in a computer and then working with it to finish the product that is the essence of engineering, irrespective of the branch. It also lends itself to a connection with engineering science. In that, from that picture, we can do analysis of its behavior.

For example, a beam, we could figure out what are the stresses in the beam. If you make an electrical circuit, we could analyze the current and voltage drops in the circuit. So, that is a connection between the drawing that we make or how we visualize the object and its underlying physical basis or the engineering science.

The final product has to have a sense of aesthetics, and that is generally looked upon as industrial design. There is nevertheless an overlap between all these three. Visualization, as we have said, is integral to design and it influences both the appearance as well as how the device will work out when different people use it.

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So, we start with today's examples, the first one being food. And here I have given some examples. And what you are seeing here is that we have made things look nice. Somebody thought that the first picture here say a pastry, it is not just its ingredients one upon the other at the end, we want to make it look appealing and make it look nice. That is an example of visualizing this particular food.

On the, in the middle here, is a very different type of an example. This is carving. So, you have taken a fruit, like a kharbuja, and you have cut it, and all of this is from that single one piece and we make the fruit look so beautiful. So, carving means you took a series of knives and different types of blades and gradually cut out what you don't want to keep and the rest gives you the picture that you want.

So, the person who was doing this had the three-dimensional image of what he wanted, and using that image, they are always figuring out what I need to remove to make this particular shape. So, the abilities there are somewhat common to in general what we call sculpturing, there, the image the 3D image in the mind, but they are thinking of all the stuff that they have to remove from the object.

The third example here is a plate of food. And you can see, how nicely it has been laid out. And at the center is a dosa, which has been made into a conical shape. So, there are colors, there are textures, there are shapes and all of them both together to make this food look very nice.

And the fourth picture here is something we are very familiar with what we may call as traditional Indian dry snacks. Your papdi, gatiya, bhujia those type of things. So, you can see how many complex shapes come out in making this simple device. There are many more applications of food. So, that gives just a flavor of what all we can likely encounter.

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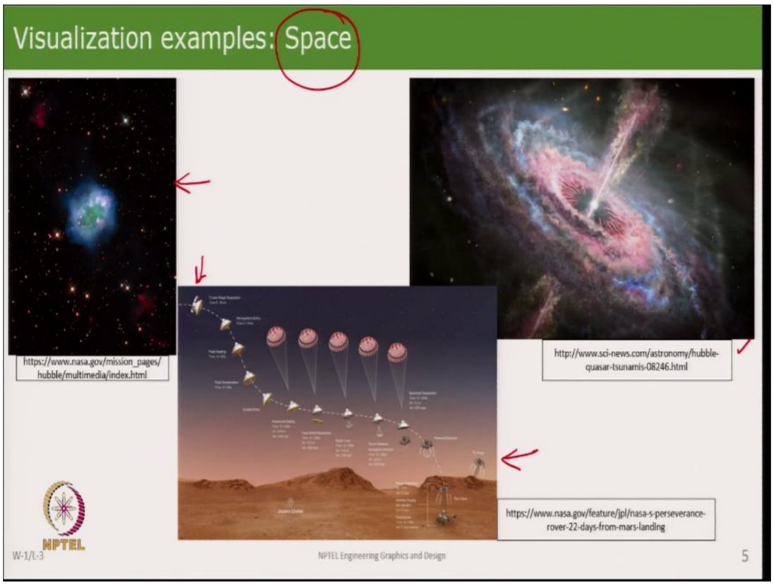

Now we move to a very different application, which is space. And this is a picture taken from NASA, using the Hubble telescope, and it is looking in the distant at some stars, and we can see an image that comes out and this is what scientists will then go back to interpret what it means, and what could it be, what could be happening there. There are colors, there is brightness, there is darkness, there are small spots, there are large spots, all of that conveys information for the scientist. And this what all the telescopes looking out into space do.

On the right is yet another picture from the Hubble telescope, and this is a very classic picture that we see, where you have something an axis in the middle, and around it is a swirling mass, and all of this is billions of light years in size. So, and far away from us, but that is what the telescope was able to see. So, this image tells us a lot about the physics of what is going on here, and then one looks at the equations, tries to solve them and interpret and see what this whole thing could be meaning.

The third picture is a more recent one. Few weeks back, NASA's spacecraft landed on Mars and it is not just moving on the planet surface, but also there is a helicopter which is flying around and seeing things. So, here in a very nice picture. It has explained a very complex idea of how the spacecraft after entering Martian atmosphere descends through it. At some point, the parachute opens up, which loads it down then, at some point the rover is suspended dropped down and then slowly the rover touches the ground, the cables snap and its vehicle flies away.

This is extremely complex and a very, very sophisticated maneuver, but in one picture, we are able to visualize everything that happened. And when the scientists there and the engineers sat around to sing well, how can we make it land, they would have come up with a lot of ideas, all of which were expressed in some picture like this, but first by sketches.

And then they would argue which one is more doable, which one is risky, which one is safe, which one is complicated all of that, and finally they come to one design, one idea and that is what they then go about doing the detail engineering and implementation. So, all of this would have started with the thinking of sketches of what we can do. That is where visualization comes in.

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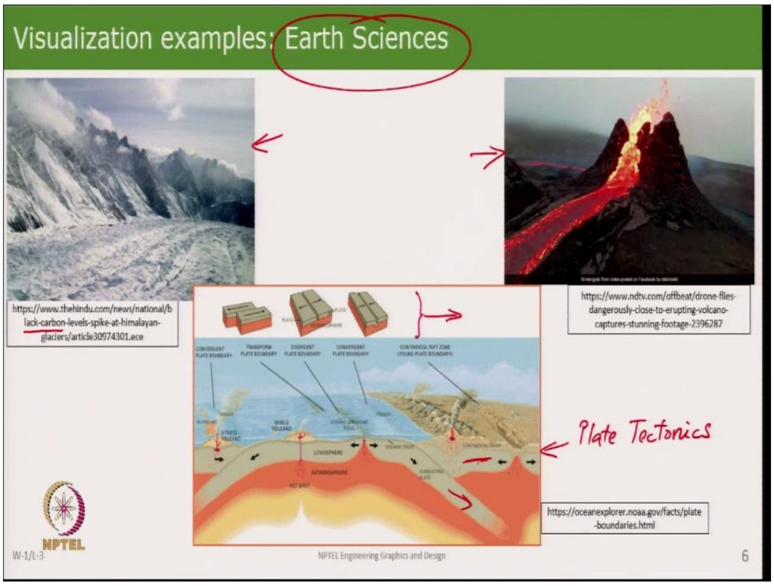

The next example is from Earth Sciences. And on the left here is a picture of a Himalayan glacier where several things are happening to this glacier because of climate change. And there are a lot of good pictures where people have photographed the same glacier from point over many months and then learned how the glacier grows and shrinks. And from there, they are able to decide whether it is growing or as we know now, almost all glaciers are shrinking and shrinking quite rapidly.

The image also tells us something else, which is there in this one, is that, because of pollution going into the higher levels of the atmosphere the snow that is forming on the glaciers is no longer clear white, but there are lots of black spots on it, which is what is called black carbon which changes the way it does heat transfer, and that affects the melting rate of the glacier.

The second example here is, the other extreme of a volcano that erupted, and this has been taken by a drone flying very close to the volcano. And you can see how molten lava is coming and flowing down and solidifying on the way. So, here we are looked at a complex phenomena and then we go back and see that what is going on here. And then by seeing, what a dormant volcano is doing, what can we predict about it? What can we look at the rocks around the mountain, and infer what would have got could have happened many, many years back.

This third picture here is about a very famous theory, which is the plate tectonics. Until about 50, 60 years ago, it was presumed that the earth surface is fixed, but this researcher, this famous professor showed that is not the case and that the earth's crust is always moving around. And that is what we are seeing here that you have water, you have land, and there is one plate, which is over here and this plate is moving below it and this continuously keeps on growing.

So, within one picture, we are able to explain the entire structure of the earth’s surface. But this of course happened by looking at lot more pictures, which would be like water levels at the shoreline, the structure of the shoreline, the color and the construction of the shorelines and then from there, one could argue that this was not a stationary thing, but something which is moving.

And there are, this is also at the top shows three things, how the earth's crust moves relative to one another. One is moving past one another, one moving away from another, and one going below another. And, of course, all these things is what we know will cause earthquakes.

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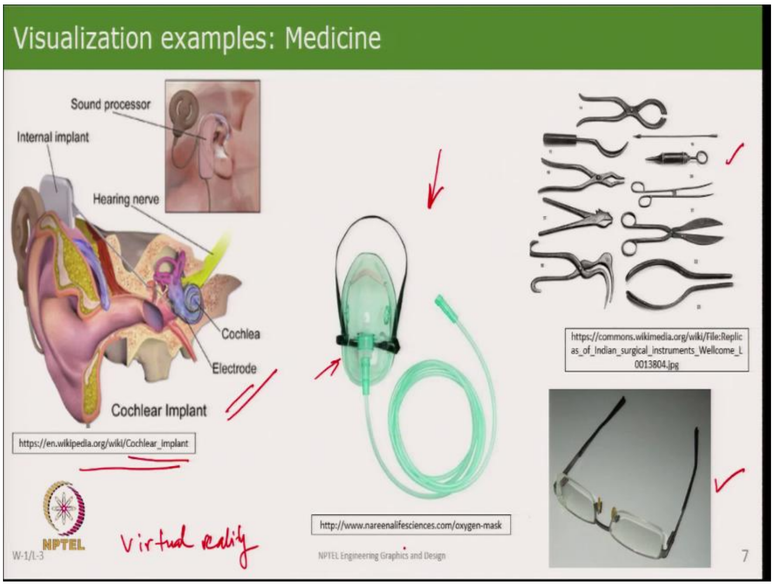

Now it gives some examples from medicine or biomedical devices. The first one here is, what is called a cochlear implant. If you have a hearing difficulty a lot of research has gone on, various types of devices have been invented, where you now put it into the ear and it restores your hearing to quite an extent. But to do that, those engineers needed to understand the construction of the ear, and the physics of it, of how an acoustic wave when it hits the eardrum produces an electrical signal, which goes as input to the brain.

So, they had the study acoustics, they had to study electronics, then they had to study the mechanical properties of the year, and then decided what the implant should be, where it should be placed, and how it should work. So, these are very, very sophisticated devices.

They may look very small, but they have really revolutionized the way where someone with very little hearing can get almost complete hearing back. But that is one example of one part of the human body.

You would see similar drawings of practically everything that the human body has and they are used for different purposes. For example, the eye, we would look at the eye for various things about not just setting which type of glasses to wear, which is what I have shown here, these are glasses, but also, we are now looking at how you can change the refractive the focal length of the lens of the eye or how now you can understand how the human mind sees something and you create pictures, and that is what we end up calling virtual reality.

So, we put on certain glasses and you begin to see a very different world altogether. Not physically there, but it has been created for you, and the mind interpreted as if you are living in other world. Glasses here looks very simple, but you just have to go to the shop to figure out how many types of lenses are there, how many materials are there, how many designs are there, what cost range is there, then you will realize that a very simple thing like glasses is not just one simple thing but a big collection of infinite number of designs.

The picture here is an ancient picture from instruments used by Indian surgeons hundreds of years ago. They had made these sketches, and then with local artisans they would make these things, and these were used in performing various types of surgery. And this picture in the middle here, this is something you would be very familiar with in this pandemic. This is the mask through which one gets oxygen.

This simple device has been a lifesaver for many. But even without the pandemic, the mask represents a lot of challenges. For example, the surface of the mask has to fit in a leakproof way on the face. The mask itself is made by a fixed design. So, there is one design, but all human faces are different. So, some masks will fit a face very well, some will not fit very well. And when it does not, which will be in the majority of the cases there will be a bypass and leakage of oxygen that is applied to the mask.

So, this is a real challenge, where you have to understand the three-dimensional shape of the face, which varies from person-to-person, and then see how a mass should be tailored to get maximum leakproofness when you put it up. So, that is a technical challenge, but it tells you that you need to first understand the image and the picture and be able to visualize it.

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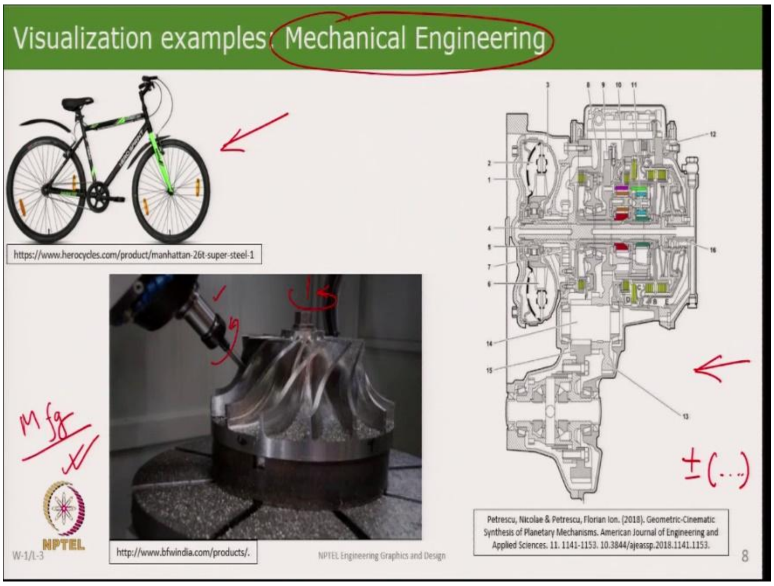

In the earlier lecture, we had looked at examples from electrical engineering and civil engineering. Now, here are some examples from mechanical engineering. In very large number of examples, we have just taken three over here. The One theory is, of course, everyone recognizes that it is a bicycle. The same good old bicycle, which has been there for about a 100 years is still the mainstay of doing a lot of things. And in the pandemic, it has probably become the biggest selling item, especially for children who cannot go anywhere.

And maybe in future if you want to avoid crowding riding on a bicycle and going to work would probably be one of the safest things to do. On the right here, is a cross section through a transmission of an automobile or maybe a like truck. And this tells you in its full glory, the complexities of mechanical engineering, but it is this picture, which is actually an engineering drawing, which tells you what all is there in it and how they are fitted and how they operate.

We would not go into the details of this, it is a topic for a more advanced course on mechanical engineering drawing, but it tells you that a simple thing like a transmission is such a complicated machine. It is a very high precision device in the sense that when you say the dimension has to be something it should be something plus minus something and that is very, very tight. That is what has made today's machines very reliable.

The third picture is from manufacturing. You can see a complex shape is being machined out from a block of steel or looks like aluminium. So, this is cutting tool. At the end of this is the tool that actually does the cutting, so this is spinning and this tool can be made to move in two, three directions, whereas, this object can be made to can be adjusted in this direction.

So, you have a combination of maybe up to five degrees of freedom of motion coming together to make this complex shape out of a solid block of a material. So, this is what one has to picture.

And while you are just making it, you also end up understanding that by making it, why make such a complex object. And for that one then goes back to understanding a thermodynamics. So, that is one example of manufacturing and there are many other techniques of manufacturing, which we do not have time here to do it. Later on, we can keep on adding to that.

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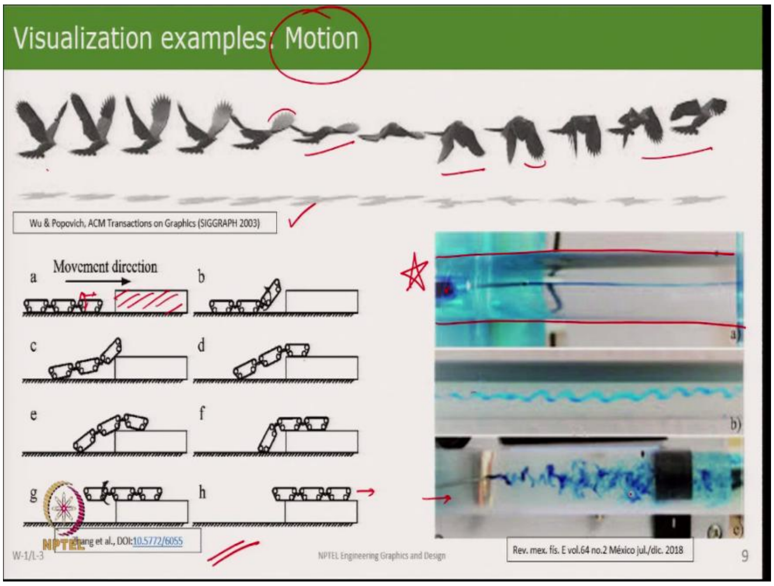

We don’t just visualize static objects, but now, we increasingly also visualize motion. Earlier, you could visualize motion is like a cartoon, you could make things one after the other or you had a cameras that took a picture for a few seconds at very high frame rate, and then you played it in slow motion to see what was happening.

There is also a case where you have a camera, which just sits there and does not take pictures very fast, but say every 5 minutes, over 24 hours, then you see what happens over a 24-hour period. These days, motion visualization has become very critical for a very large number of applications. Practically anything that we do where there is motion, we need to see how things will happen.

So, on the top here is a picture of how a bird flies by flapping its wings. We would not go into the details of each and everything, but it tells you that it was wing was there and then how the shape of the feather, then what happens to the wing, then it goes down what is happening to the tips here and then when it comes back up again.

All this is extremely sophisticated, because it has been perfected over hundreds of years of refinement by nature, and that is we as engineers try to learn. What can I learn from this bird to make a UAV a better flying machine? So, visualizing this picture is central to that. This picture here is visualization of an object with 4 things connected to one another, which can move and they are looking how this object can be made to climb a stair.

So, this is the stair. This object can move this way and about its connection, it can go up and down like that, it has got its own drives in that. So, it comes here, we can see it has gone up, we have shown this goes up, then it touches there, the next one comes off the ground, then the first one has gone up and they are now in midair, then it continues forward motion then the second one reaches up.

Finally, two are up, one is pulled on and this object has climbed a stair. This is one of the ways in which you can make things climb a stair. There are many more devices available in the market where you can there is a chair, which you can sit on the chair and could climb staircase. But point is this, that we are able to visualize this motion in pictures. And while qualitatively the picture may just look like an idea that can be made practical actually, we have solved the equations of motion of all this to make it engineering possible.

This third example here is very different. This was, these two were visualization of a solid object. What we often do is, we want to visualize the motion of say air or motion of water. So, here there is an example. What you are seeing here is a tube, circular tube in which water is flowing and we inject a little bit of dye like say a strong solution of potassium permanganate.

And under certain conditions, you can see that it does go straight as a very smooth line. In fluid mechanics, we call this a laminar flow. Then, as you increase the velocity, it begins to become a little wiggly. And at even higher velocity the flow rate of water has increased. It goes in and very quickly becomes completely random mixes up all the way. This is what we call a turbulent flow. And that is how we discovered many important things about fluid flow and the engineering of devices, which handled fluids.

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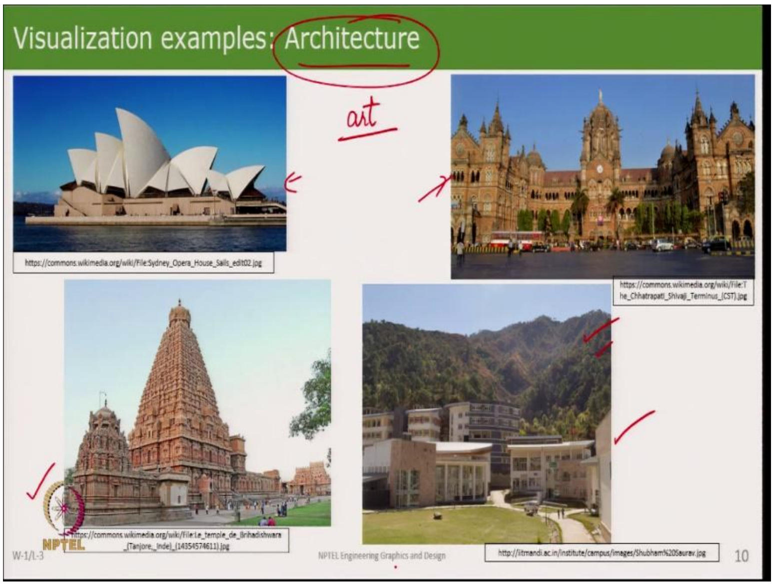

A few examples now from architecture. It is a blend of art and engineering. So, there is a good connection there. On the first picture here is the famous Sydney Opera House. Looks like sales, a very tricky to make. The civil engineers were told to make a structure, which for them from stress analysis and other viewpoint was not a very good structure, then there to innovate, innovate and make the architects wish, come true.

On the right, this is CST Terminus at Mumbai. You can see the fact that the building is there, but outside it has got so many features that make the building look very distinct and very appealing. The third picture is a famous British for a temple at Thanjavur. The sheer size and the complexity that is there in the temple is quite impressive. And one can see that in a world of engineering, how would you go about even thinking of making it.

And then you think back thousand years ago, how did the designers and the workers were able to decide how to make it, which stones to get, how to cut them, how to place them and make a near perfect shape. They had their own way of communicating with one another. Today, it is a slightly different way, but the fact was that there was conceiving the idea in a mind making some record of it, communicating it to others and then making such thing happen.

This fourth picture are buildings of a campus. And one can see that this is like typical, you would like to make a building or an apartment block or an office block or a campus that you put down your requirements and said this is what I want to do this is how people should move. This is how people should interact with one another. I want to make buildings that help people be more happy, and then you start putting things together and finally you get a campus, which you would like to be harmonious with nature, with the mountains and the valleys and the rivers around it.

So, that is an example of building designs, building materials to be used. Of course, we are now looking at what is the carbon footprint, what is the eco-friendliness of the building all this is very important.

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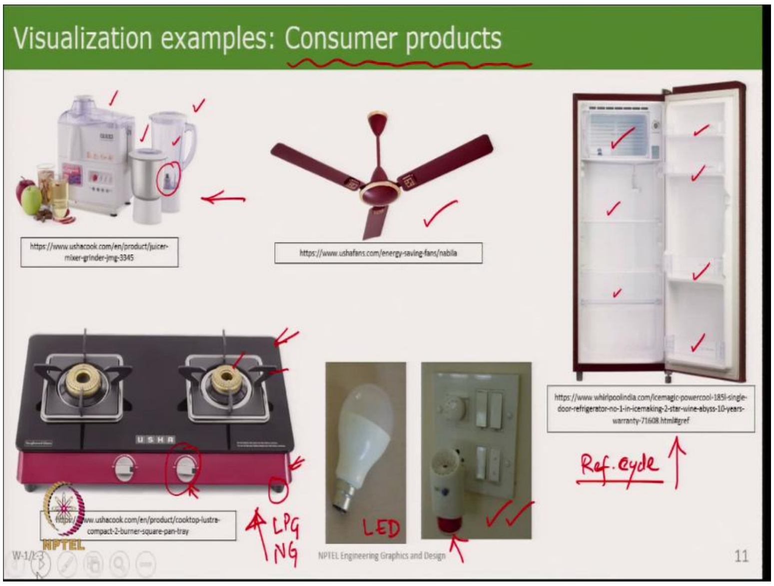

Now with examples from consumer goods. Most of us use many of these. The basic thing is, when you get electricity to a house the first thing we have is switches and plug points. And along with that and I have also shown here something which is there everywhere a mosquito and a mosquito repellent being put there.

Then we have a light, so that is an example of an LED bulb and these are changed. 20 years back there were CFLs before that there were the incandescent bulb for almost a century. Now that incandescent bulb is gone to history, we are left with LEDs. And then after we get these basic things in a house our next thing is a ceiling fan.

And you only have to go to a website of any of the fan manufacturers to see the variety of fans that they have and look at shapes, sizes, colors, designs, so many things that they are able to make. Besides these we are seeing here a food processor. So, in this one can put in fruits and make a juice or one can put a grinder and make a chutney like that so there are different things here. They all attach to this and one can operate that.

But you can see there are various shapes in this. Inside this there is a blade whose shape is made in a certain way. And you would always like to see well how can I optimize that and the shape of this jar, so that whatever I want to do happens in a shorter time of better quality and possibly with less noise and less energy consumption. This one here, your cooking stove, which can work either with LPG or natural gas or PNG.

So we see, somebody made this drawing, and then it was manufactured. So, you have a frame there on top. This is typically a glass. And so you are saying, you have made the surface of a stove with glass, something that we learned in school that glass is very brittle and does not stand high temperatures. Well, you are saying that that is limited in its application, one can get around with that.

Then we see a burner, the stands for placing the vessel, knobs for control, then stands for placing it, and all these started off as an idea somewhere and then made of they were manufactured. The burner itself, you would like it to be as efficient as possible, so that over the range of settings that we have it gives us a nice clean blue flame with almost complete combustion.

And lastly, here, a refrigerator. So, we have seen the inside part of the fridge. And you can see in the door, there are various features in this. Inside this, there are different features, there is a freezer over there. And then you look at the body, you look at the other machine parts of this whole system, which is typically a refrigeration cycle. And then we make it all look very nice and functional, with easy to clean, easy to access, all of that happens in this.

So, those are some examples of consumer products. There are many, many more. We can keep on adding as we wish.

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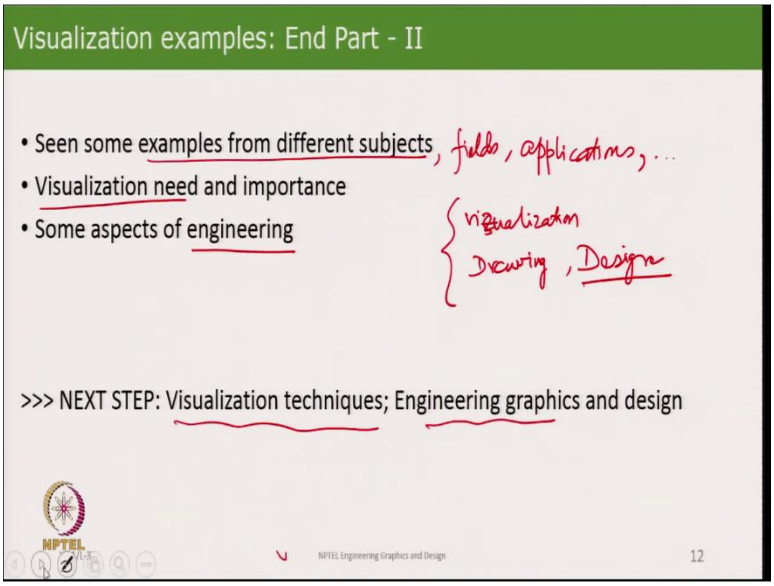

So, with that, we come to the end of these set of examples. And in part 1 and part 2 put together, we have seen examples from different subjects, from different fields, from different applications. And what we have seen is that this idea of visualization or drawing and design they have applications across a very wide variety of disciplines. And that is the ability that we would like to have, when we go about working as designers or innovators.

So, that is the thing we saw there. The need for visualization and its importance. And then in some examples, I talked a little more about the engineering aspect of that device. So, that would be a beginning thing. So, it tells you that you want to do the engineering of the product. If you are doing a design, you start with an idea, you make a drawing and then you do the analysis. And if you are doing reverse engineering, then you already have a product, then you go backwards, dismantle it, see what is in it and get a complete understanding.

That understanding will never be 100 percent complete, because they are very fine items, parts of that design, which only the manufacturer knows. So, where do we go from here? We will then in next lecture, we will look at visualization techniques and its applications to engineering graphics and design, which is the title of this course.

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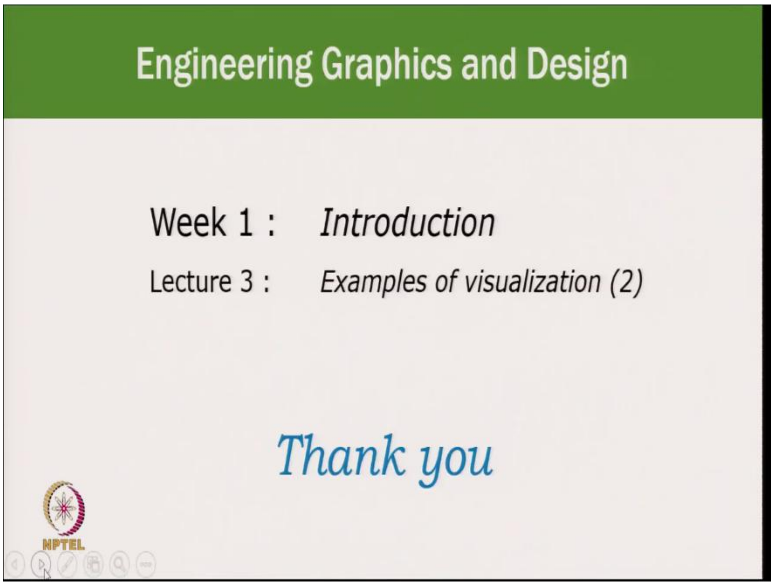

So, with that, we end this second lecture on examples of visualization, and the third lecture on the first week. Thank you.