Engineering Graphics and Design
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Week 7
Working Drawing

Welcome back to this course of Engineering Graphics and Design. We are on week 7. In this week we will be looking in to working drawings. So to understand working drawings,we are working with devices.

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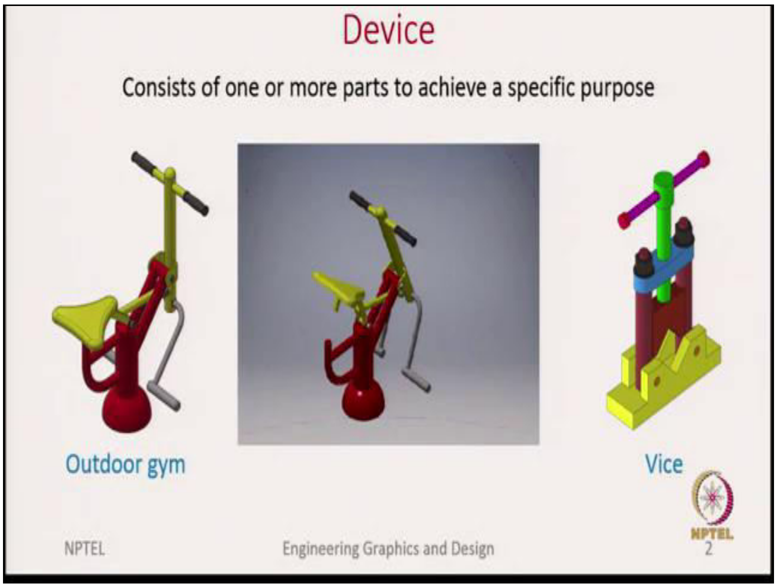

So, first let us look at devices. Devices consist of one or more parts to achieve a specific purpose. So there are devices which have only one single part. For example if you think of a wrench, used to tighten a nut, that is a single part. But it is still called a device. Similarly, there can be other devices. So, you can think of a scissors. So, if you think of a scissors, it is a collection of few parts, like it has two hands and then joined at with a pin.

So, it is now a device, because it is done to cut things. And it is having multiple parts. So, here are two examples of those devices. One is an outdoor gym. Most likely you should have seen these in parks. Essentially, what it does is using arms and legs, you can lift your own weight. So, to give a clarity I have an animation. So, as you can see, ones you pulling the handle bar closer to you, the seat rises or the person seating on it is raised up.

Next example is a vice. Again, this is a common tool used in most machine shops or any fabrication place. Essentially, what it does is to hold any object between two v-shaped vice.

So, essentially when you turn the handle at the top, this upper vice comes closer to the bottom jaw and holds the object. So, let us say, you are the designer who is developing this device.

What happens is you may need others help to fabricate this device. So, let us say you are done with the designing of this device. And then you need to fabricate, then you need to communicate with a third party. So, let us say it is a manufacturing shop, then how do you communicate your ideas to them? So, the way you communicate your ideas to them is with a set of drawings. Those set of drawings, what are called as working drawings.

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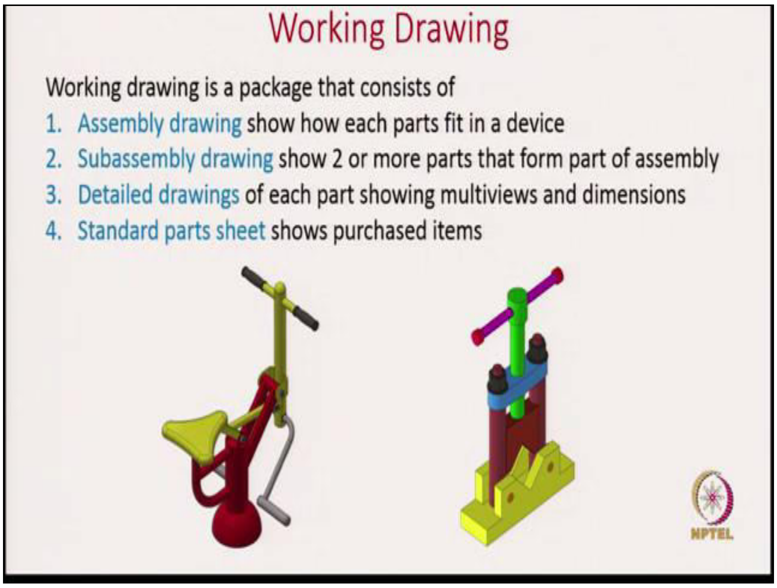

So, essentially what is working drawing? It is a package that consists of few drawings. So, let me list down, one at a time. So the first thing you will give them is the assembly drawing. What does an assembly drawing do? It shows each parts how it fits in a device. For example, if you notice, any of these devices, you will see that it has multiple parts, may be some close to 7, 8 or 10 parts.

But, what we are seeing here is all those parts coming together, so that they fit and then you see the actual device. So that is what the assembly drawing does. So again on this slide, I show you these colorful pictures. But, essentially an assembly drawing is like any projections we have been doing in the previous weeks, like the multi-view projections, orthographic, isometric.

So, depending on the complexity of the object or the purpose for which you are developing these drawings, you will choose either a multi-view or an isometric view of this assembly, to convey the idea of this device. So, we also show the subassembly drawings. So, the examples what we see here might look a relatively easy because they are composed of just may be 8 to 10 parts. But, let us think of a car.

A car is also a device, and it has thousands of parts. So, how do we show all of them in one assembly drawing? It is hard to see. So, think of the engine. Engine itself has hundred parts and similarly if you even think about a wheel, even a wheel has many parts, because you have the rubber tire and then the rim and bolts and nuts to fix it. So, each of these you can consider them as subassemblies.

So, one you can say the engine is one subassembly and then the wheel itself is a subassembly. Similarly, if you are looking at steering wheel, you might see there are several buttons and other options. So, even this is a subassembly. So, essentially, when you want to convey the design of this car, first you will start with a assembly, which shows the complete car, but then you will say this total car is composed of subassemblies like what we have been discussing, the engine, wheels, steering wheel, seat, or other, gear box, for example.

And then, once you dive into subassembly, again, you will, what you will notice is, it is again composed of multiple parts. That is, when for each individual part, if you draw a detail drawing, that will show the actual dimensions of each shape of it and size of the part. So, essentially, we need detail drawings at an individual part level but when we go at the subassembly and assembly level, we are not more interested in the exact details of the dimensions, because we know those will come into the detail drawings.

But, in the assembly and the subassembly, what we are essentially looking at is, how these individual parts come together and sit together, so that they perform the task what they are designed for. And lastly, we will also have standard parts. So for example, if you look into the vice, in the example 2, we see there are bolts and nuts. So, these are usually standard parts, which we can go and buy in a hardware store.

So, essentially, these are not the parts, where, you want someone to manufacture and bring it to assemble the device. But, you can directly get of the shop of the shelf components, these are called. So, sometimes what happens is for these standard parts, depending on different industries or the different companies follow different procedures.

Some of them want you to just list out those parts and some of them still want you to show the drawings of these standard parts. Essentially, there reason being that they want to ensure that these parts assembles well with the device which you are working with. So, that the tolerances, fits and all are ensured. So, all these together makes a package which we call it as a working drawing.

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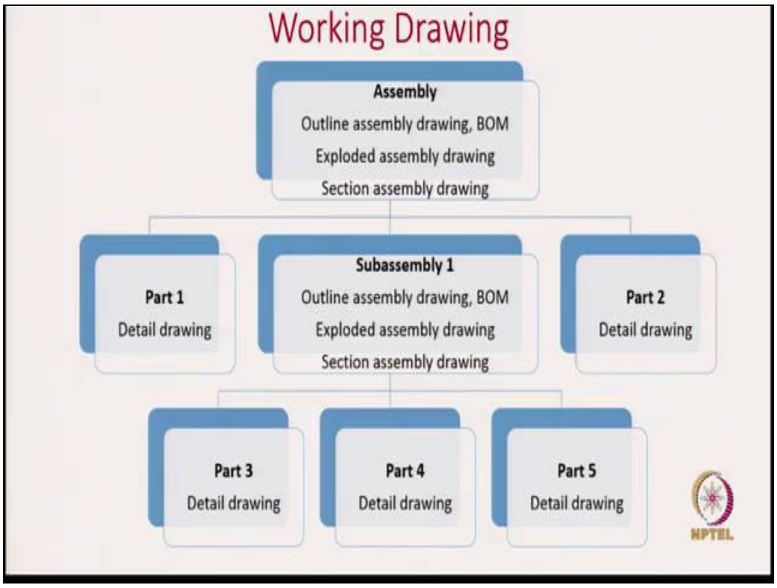

So, let me show you the same working drawing, we have been discussing in a flow chart. At the assembly level, we see multiple drawings, called as the outline assembly drawing, exploded assembly drawing and the section assembly drawing. So, we will be looking at each of them in the next few slides.

We will be also looking at something called BOM or the bill of materials. So, essentially it is a list of all the parts in the assembly. But, to start with, we start with the assembly, and show the assembly in three different manners. You may choose one of it or all of it, depending on the purpose, why you are drawing the assembly.

But essentially, what we are trying to say is, this assembly is composed of let us say, part 1, part 2 and subassembly 1. So, if you bring all these together, you get the main assembly. So part 1, part 2 and the subassembly. But, subassembly itself is an assembly, which is again composed of multiple parts. So, let us say subassembly 1 is again composed of parts 3, 4 and 5.

You will notice that the detail drawings are only with the parts. So, each of these parts have a detail drawing where the actual dimensions and multi views are shown, so that, the shape and size is depictive. Whereas, when we come to the subassembly and the assembly level, we are only looking at how these parts come together and perform the operation of the how to you convey the design. So, all these drawings together make up the working drawing.

So, now let us look into these outline, exploded and section assembly drawings as well as the bill of materials, such that, we know how do we show your designs to the other party.

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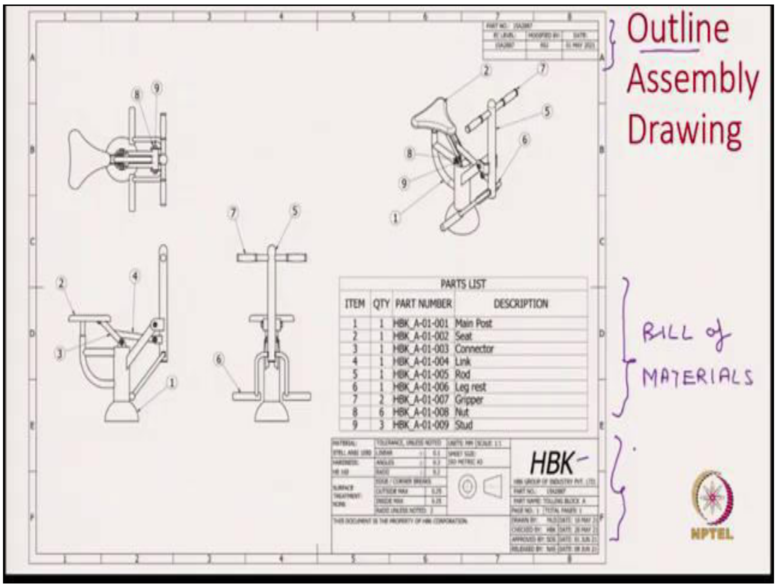

So, here is an example of an outline assembly, which we draw for the outdoor gym we have seen earlier. So, here there is a lot of information in this one single drawing. So, of course, you can see the multi views of the assembly, as well as the pictorial or the isometric view of the assembly. So, as we have already discussed the pictorial helps you to get a quick idea of the design, whereas the multi views helps to give more precise information about each individual component.

But in addition to this multi view and the pictorial view, we also have additional information sitting on this drawing sheet. Previously, if you remember, we talked about the main primary title block or the main title block, which is this part of the drawing as well as the secondary title block. Essentially, what to we have here, we have the company, who is owning this design as well as the people who have drafted, designed and approved this drawing.

We also have details about the drawing, like which angle of projection we are using, first or the third angle. And what sheet we are using, are we using A3, A2 or A1 sheets as well as the units used because as we know, depending on the country, sometimes people use either SI units or the metric system. So, all that information needs to go into the drawing such that when someone starts reading, they interpret as you desire.

So, in addition to all these information, what we find in the title block, we also have this, which we call as the bill of materials. So, now let us look into closely each of these in the next few slides.

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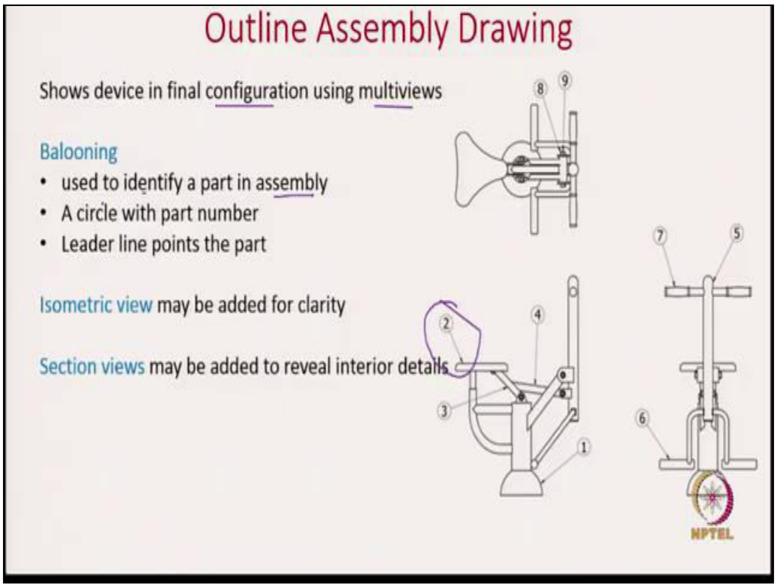

So as we said, the reason why we use the outline assembly drawing is to show the device in the final configuration using multi views. But instead of using multi views, we can also use the pictorial to quickly show the design. So we use a concept called ballooning, to show the different parts in this assembly. So it helps you to identify the parts in the assembly.

And how do we do that? At this ballooning, which is part 2. So as you can see, the item number is written as number 2, enclosed with a circle, and then you have a leader line, which takes you to the part. So you use an arrow at the end of the line to show the path. So it should be noted that this ballooning should be done only once, let us say one bolt, which has a quantity of 4, you need not show that bolt as item number 4, at multiple times.

You just need to show it once. And it is understood from the drawing that there are 4 quantities, because that information is anywhere there in the bill of materials. So again, reiterating the point being, we only show the item number once in a drawing. Next, as I already mentioned, isometric can also be used for clarity purposes.

And section views may be used to show the interior details. Sometimes, just by looking at the outline, you may not see all the parts, because some of the parts are hidden. So to show those parts, then you may have to use the section view, so that all of the parts can be shown in the assembly.

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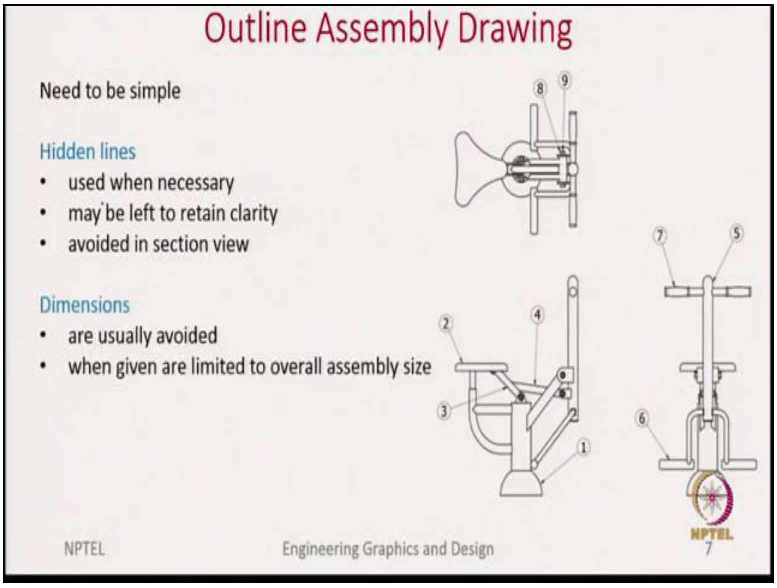

And whenever we make these assembly drawings, we need to make sure that the drawing is simple, and we do not make it complex. So how do we make this? By following few practices, one for hidden lines. We can use hidden lines when it is necessary. But they can also be avoided, especially in section drawings because in section drawing, you already have those hatchings to show the different parts. So we do not want to complicate the drawing by including these hidden lines.

Next, regarding the dimensioning, again dimensioning should be avoided because we do not want to complicate the drawing as well as to make it complex, so that it is becomes difficult to read the drawing. But sometimes you still go ahead and do the dimensioning, especially, when you want to show the overall dimensions of the assembly, as well as to show, what is the distance between few critical parts.

So those are the details which you cannot show it in a detail drawing. Because the overall dimensions of the assembly or the relative distances between parts cannot be shown in a detail drawing. That is the reason why in particular instances you show those dimensions in an assembly. But otherwise whatever you can show in the detail drawing, you should avoid it in an assembly drawing. Okay.

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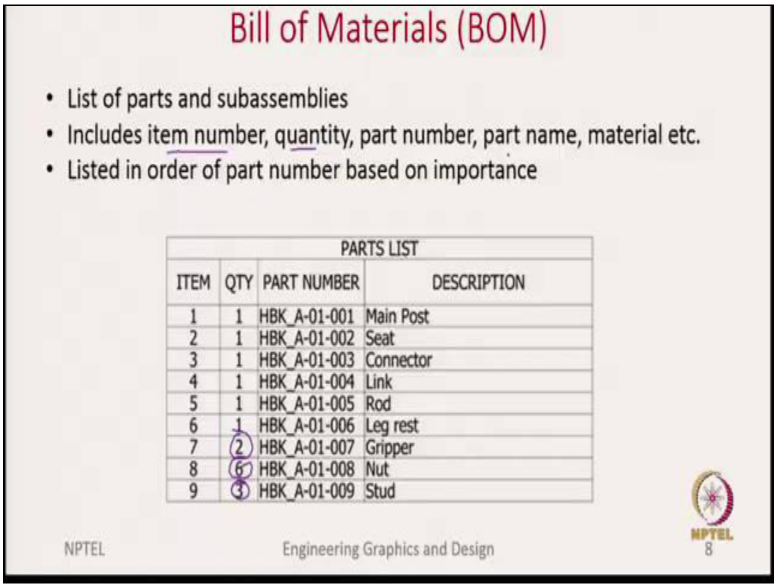

So next let us look at the bill of materials. We have already seen what the bill of materials does. So whatever parts you have shown with the ballooning, you make a list of those parts and show it here. So what does the bill of materials contain? It contains the item number. It also contains the quantity.

So for example, here, you see the gripper the quantity is 2. Similarly, there are 6 nuts, and 3 studs. So in addition to the item number, and quantity, we also show the part number and part name. So one thing to note is a part number and a part name is a must for each and every individual component, as well as a sub assembly and assembly, because these are the pointers which people use to trace the designs.

So, for example, let us say one year down the line, there is some maintenance or the change of design happening. So people need to identify each and individual part with a part number, so that they can go back to the design of that particular part and see if any modification is to be done. So these are not just to the parts, but even for the sub assembly, we have a part number and a name.

And though I did not show it in this bill of materials, sometimes you can also show the material by which it is made. Usually, steel, aluminum or a particular alloy used to prepare these particular parts, can also be mentioned in the bill of materials. The reason why these bill of materials is important is, because if you have a design and you want somebody to fabricate it for you, they can quickly estimate, what are the activities they have to do and what is the budgeting they have to do, to fabricate this object.

That information is available, of course through the assembly drawing, as well as through the bill of materials. The same thing happens not just in mechanical engineering, but also in the civil engineering, let us say buildings, bridges and all. So usually there is a contractor who is bidding to say how much he will spend to complete this project.

In order to do that he needs information about not just the overall design of it, but the finer details about what is the quantity of each and every member of it. So once we has all this information that is when they will be in a position to bid for a particular project.

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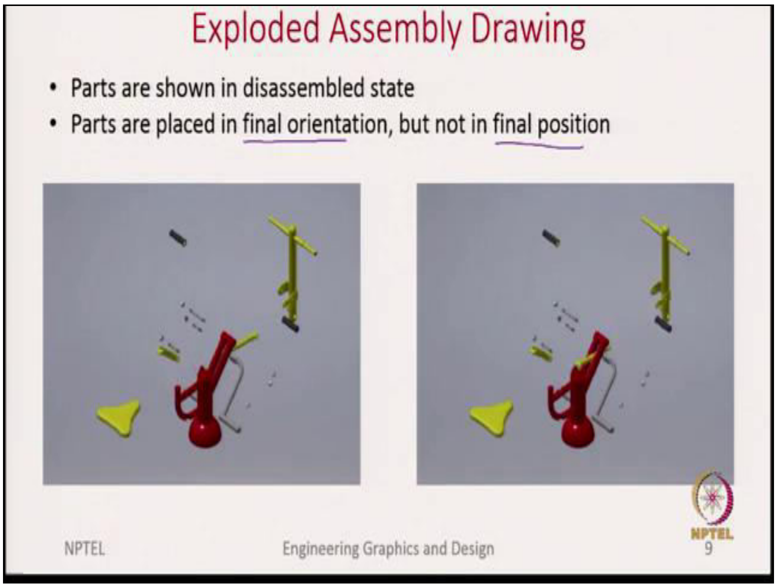

Exploded assembly drawing is another way of showing the assembly. Usually this is done for non-technical people, because you can quickly convey your designs to them using pictorials. Essentially what is done in these drawings is, you show all the parts in the final orientation, but not in the final position. So I will show you in with a quick animation, about what we meant by showing them in the final orientation, but not in the final position.

As you can now see, now each of these parts are moved away from the assembly. But when they are moved away, the final orientation of each of those parts is retained the same. The only thing is they are moved away in such a fashion that none of these parts overlap with each other. So the purpose is to show all of those parts without overlapping with each other, but maintained in the same orientation.

The whole idea is to convey to the designer or to the viewer, how these parts assemble together. Because let us say if you are giving this design for someone to fabricate, after they fabricated, they also need to ensure that they can bring all those parts together and then it should work as intended. There is another way of showing this in the reverse process.

So for example now we will show how each of these components in the exploded view come together to make up the final device. Because this is the information which a fabricator needs to know so that after he fabricates each and individual part, he can make sure that he can bring all of them together and then this device starts to function. So, this has done only for visualization purpose, but usually how it is shown in a drawing is this way.

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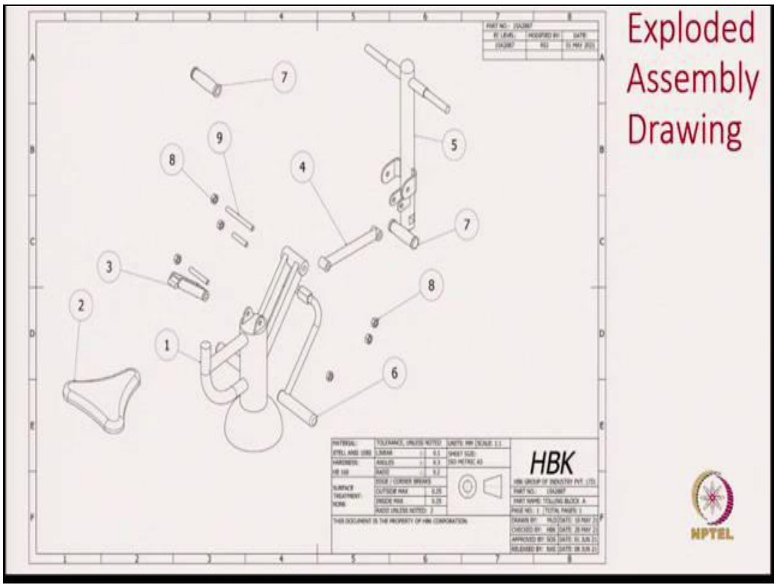

So we only show the exploded view after it is moved away from the device. And as you can notice each and every part is labeled using the ballooning technique which we just discussed.

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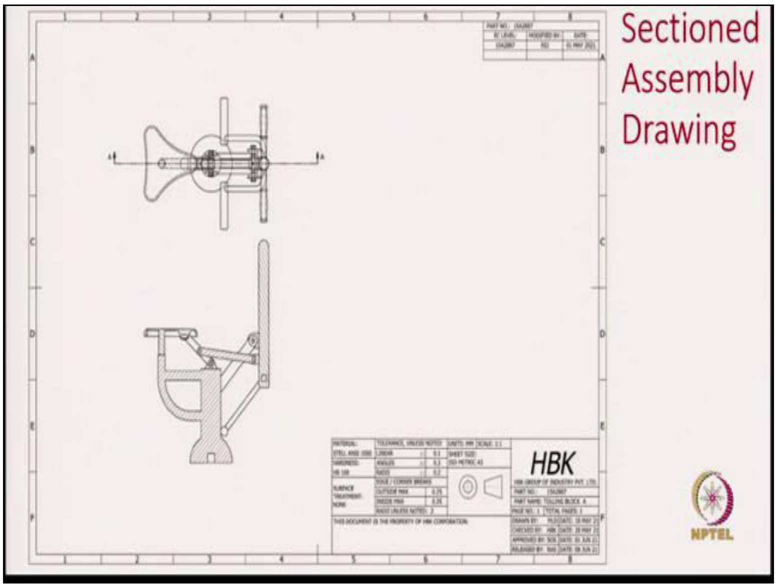

So, the last way to show the assembled drawings is through sectioning. So we already discussed about sectioning of individual parts in the previous weeks. But now what we are saying is, how to we show the total assembly using sectioning. The reason why we use sectioning, is to show the interior details of the device.

So whenever we do sectioning, we need to mention what is the cut line. So what is the cutting line where you make the section and then show the section view? For example in this in the top view, the Section A-A line shows, you the sectioning line and in the front view, you show the section view. So there are a few details one need to keep in mind, when drawing section assembly drawings, we will go through them quickly.

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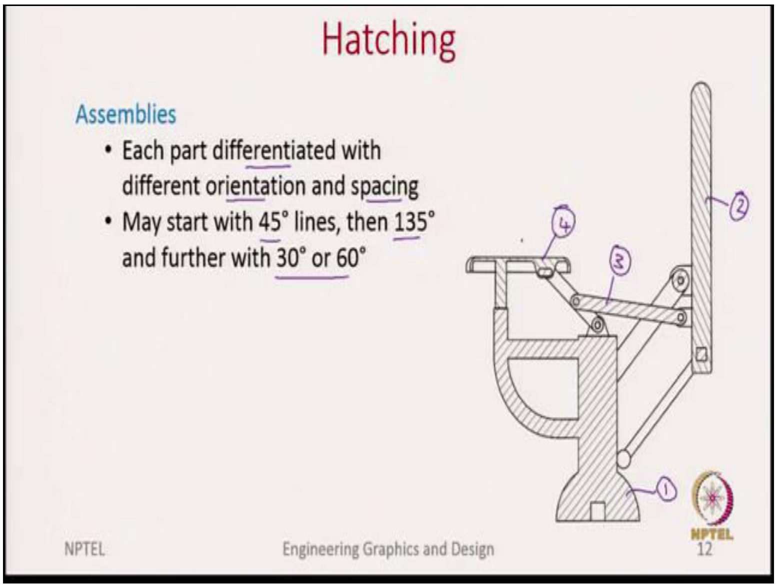

First thing is, each part needs to be differentiated, using different orientation and spacing. So when we do the hatching for the sectioned areas, we need to keep in mind a few principles. First, we should be able to differentiate each of these parts. How do we differentiate these parts? But using hatching of different orientation and spacing.

Here is one guideline to see, how do we choose those hatching line or the section lines orientation. First, we may start with a 45 degrees line then with 135 degrees line and later if there are even more parts, you can choose other angles like 30 and 60 degrees. So for example, in this outdoor gym example, this is let us say is part 1, where we used 45 degrees line and then this is part 2 where we use the 135 degrees lines.

And similarly there are other parts where we use the 30 and 60 degrees lines. So, the idea is to differentiate each part by, showing the hatching in a different fashion. In this example, I have only changed the orientation, but one could also change the spacing between these section lines. So that one can quickly see that these two parts are different.

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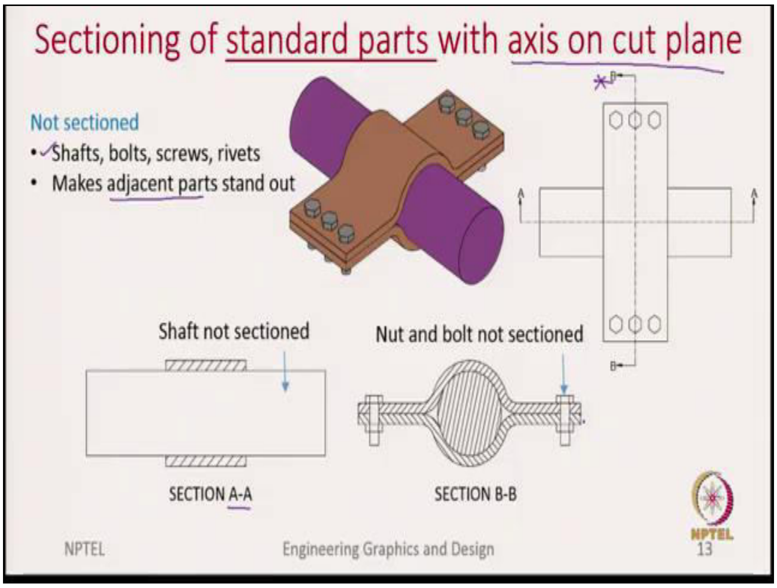

This we have already mentioned previously saying that there are some instances when even though your section plane cuts the object or a part, sometimes the you need not do the hatching and what are those special cases we are saying we do that first standard parts and especially when their axis is on the cut plane. So this is very important to say that the axis of the part should be in the cutting plane.

So what are the standard parts we are talking about? We are talking about shafts, bolts, screws and rivets. And we say that the reason why we do not show the sectioning is, to ensure that the other adjacent parts stand out. So we do not want to focus more on the standard parts but instead on these custom parts where you have this design. So how do you make them standard? By ignoring or avoiding hatching to the standard parts.

So this is the top view of this assembly, we have two section lines Section A-A and section B-B. Let us look at them and see how do we implement this practice. So first starting with Section A-A, Section A-A we have seen that this shaft, the axis of the shaft is on the cutting plane. So we see that the shaft is not sectioned.

However, this clamps which are coming on the top and bottom, they needs to be hatched because they do not fall under the standard parts. Similarly, this section B-B, in Section B-B, what we notice is for the bolt and the nut, we do not do the sectioning. Again, if you look closely, we see that the axis of the bolt and the nut fall on the cutting plane.

That is the reason why, though they are standard parts, we do not hatch. So these are the standard parts for which the axis falls on the cutting plane, and therefore we have not hatched. So, let us apply these principles to the examples we have been discussing.

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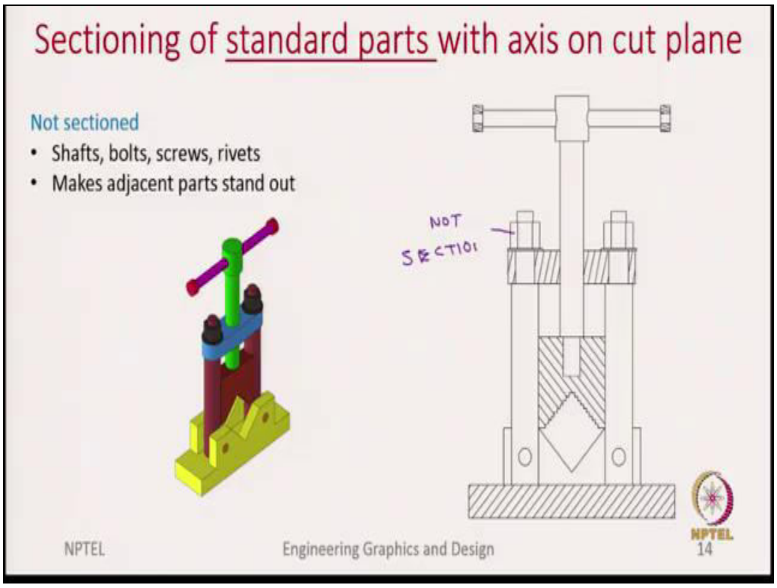

So, here is an example of the vice, we have been discussing. So we said when we section it with a cut plane, let us say this cut plane passes through this handle, and it is a vertical plane which cuts it symmetrically. So, we again notice that the bolts and nuts are not sectioned.

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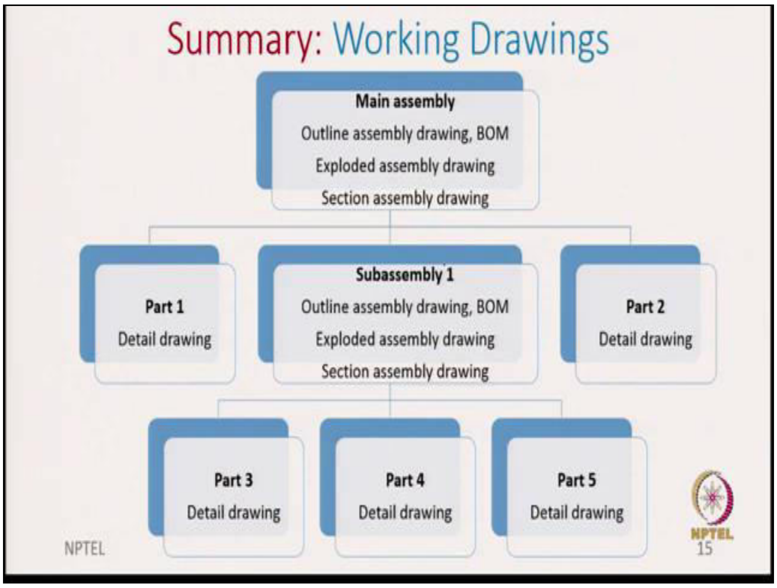

So, in summary, what we have discussed in this lecture is to say how do we convey our design to a third person. So, we convey our design through a set of drawings which we call it as the working drawings. And what is these set of drawings composed of? They composed of assembly drawings. Assembly drawings include the outline assemblies, exploded assemblies and the section assemblies.

And when we discussed about these section assemblies in our examples, we have only showed it for multi view projections, but section assemblies can also be done at the pictorial level, depending on what is the purpose of who you are showing these drawings to. So if you are showing these drawings to a non-technical person who is not so exposed to these projections, then usually we show the pictorial projections because those are easy to understand.
But if you want to convey more precise information, that is when we go to the multi views, but again coming back to this working drawings, in addition to these 3 kinds of assembly drawings, we also have these bill of materials and whenever we have an assembly we mentioned that it is composed of individual parts as well as subassemblies, depending on how complex the drawing or the device is.

For the example of a car we discussed, we said of course we need to go to subassemblies other ways, there are like 1000s of parts which we cannot show in a one single assembly. So we need those subassemblies which will take care of engine separately, wheel separately, steering wheel or the gearbox, all of these separately. So essentially, the detail drawings are only shown at the part level where all the dimensioning hidden lines and all features needs to be precisely shown without any chance for misinterpretation.

So I think this gives us an idea about what a working drawing is. In this course we will be focusing more on the sectioned assembly for practicing purposes. But as a practicing engineer, we need all these set to go to the fabricator or a contractor so that they need not come back to you for small details. So though they can call you anytime but your drawings should be a standalone piece, which means they should be able to communicate each and every details of your design, without the people contacting the designer again.

So this lecture will be followed by a practice problem, which will do it on a on a paper. So we encourage you to go through the problem, you too, also practice it, so that you will have hands on experience. Then you can do some practice problems on your own, such that you can build up your skills independently. Thank you for your patience.