DIETER SCHLAEPFER: All right, well it's 8 o'clock in the morning. I hope you're all bright and awake. No? I'll try to do my best to wake you up. I'd like to welcome you to an introduction class, to AutoCAD 3D modeling. I like to give a little bit of a description of what my intent is with this class.

First of all, I assume that you're reasonably familiar with 2D AutoCAD, number one. If you're not, you'll get some general principles. Number two is there are arguably 121 commands and system variables that are directly associated with working with 3D. I'm going to teach you 10. I've boiled it down to what I think is the smallest subset I can reasonably teach somebody, and that they'll be able to then learn other things and pull in other things as needed.

So that's my intent. This is a 90 minute instructional demo. I'm going to be switching back and forth between slides and AutoCAD a bit. There are some tips and tricks in here, but that's not my focus. I'm going to show you how I do it. I've been doing it for quite a while now. I started 3D modeling in 1980, to give you an idea. So I've developed my own ways of doing things. But that is not to say that other people have different ways. I'm going to show you what works for me. So there's going to be some tips and tricks, that's not what this class is for. It's to get you ramped up.

Now there are some course materials. And course materials include a zip file with 24 solid models, most of which I will have demoed for you, and there's a few extra ones. So basically I'm going to turn you loose and after this class is over, after you get back and the dust settles, you can go back and you can actually go through my presentation and figure out what I must have said.

AUDIENCE: Are they recording us?

DIETER SCHLAEPFER: Yeah, they're recording, so I don't care. All right, so another thing I want to mention is that I gave you a bunch of resources in the class notes. This class in particular, I said, OK, so where do you go from here? If you want to go into rendering here are some topics to look at. If you want to go into exporting STL files, or various other things that you might want to do, here are some places that you can go to. So there's some resources in your class notes.

So just out of curiosity, how many of you have worked with 3D already somewhat with AutoCAD? Oh, great. You all have. What can I teach you? OK, so a lot. All right, are any of you going to be teaching AutoCAD 3D as well? OK, so you're free to use some of this stuff, some

of the ideas, change it around, make it work for you.

As an instructor, one of the things that I've learned over time of teaching many, many engineers is that no matter how smart you are, learning is chemical, and you can't rush chemistry. And you can only learn so much in a day. That's it. One of the key elements of learning is sleep. That's how you get information from your short term memory into your long term memory is sleep. Please don't do it here, save it for later.

So as a result, what I'm doing is I'm trying to keep the amount of information to a minimum. I am going to do a couple of deep dives and show you some things that might trip you up, but again, that's not my purpose. My purpose is to get you ramped up, feel comfortable with 10 commands. All right, let's move ahead. Any questions before we begin? All right.

OK, you've probably seen this in the class syllabus. I won't bore you with reading it. Already I mentioned these are my purposes. And let's start with a few definitions in AutoCAD. In AutoCAD, there's something called isometric drafting. This is flat as a pancake. This is for very simple McMaster-Carr kind of illustrations. You can do that.

It's a little bit of a toss-up. If your parts are simple enough, sure, you can do it this way. It's almost as easy just to make them in 3D as far as personally. I mean, it's fun, it'll work. Wireframe modeling, this is what I started with back in 1980, or was it 1880? It was 1980. OK, so the 3D wireframe modeling was very useful then for visual interference checking, and for a whole bunch of other things. Really useful. But even with solid modeling, I advocate creating wireframe models as substructures as reference geometry. Very important. Because in 2D drafting, it's easy to make a mistake. You know what that's like. With 3D, it's much, much easier. One beer, you're toast.

Surface modeling. Think of the term paper thin. That's surface modeling. AutoCAD is a hybrid modeler, and it's got surface modeling in there. We're not doing that. Mesh modeling, AutoCAD also has mesh modeling. Think of chicken wire, that's mesh modeling. You can deform it, you can smooth it, you can turn it into a solid, you can have a lot of fun. We're not going to do that either. But we're going to do some other things that are fun, I promise.

OK, so 3D solid modeling, that's what we're going to focus on. And it's a blast, it really is fun. And I eat my own dog food, as they say. I do a lot of home projects using 3D, and it's worked out great. So anyway, that's our focus. Those are some basic definitions.

Now this is the structure of what I'm going to be covering. I am going to cover some 2D commands used with 3D solids. Why am I doing this? All it is is a fast forward. It says, when I do 3D solid modeling in AutoCAD, those are the 3D commands that I find myself using the most. If you use different ones, then you might ask yourself, OK, why am I doing this? But these are the ones that I use.

So viewing in 3D, user coordinate system. How many use it in 2D drafting for drawing 2D stuff? OK, 3D it's absolutely essential. Now we have some profile operations, some Boolean operations. I'm going to give you some bullets of best practices and advice. And then next steps, where do you go from here? I'm going to keep the amount of information, again, to a minimum. So I'm trying not to overwhelm you.

All right. These are the commands I use the most. Recognize them? OK, so great, you're already halfway there. Super. PEDIT, ortho mode, direct distance entry. I almost exclusively use that for rectilinear parts. PLINE, rectangle, circle. You might say, Dieter, why don't you use 3D poly? And the answer is because I can't fillet 3D polylines. I can fillet 2D polylines. So think of a pipe with elbow joints, and I can have the elbow joint coming this way, and then up, and then the elbow joint going forward. There may be some routeing things that you can do with 3D polylines, OK, that's fine. But if you want curves in them, that's why I just use the POLYLINE command.

OK, boundary. Anybody use boundary? OK, I use this all the time. If I have a 2D drawing with stuff in it, I use the boundary command to generate typically a polyline within those boundaries. I use those as profiles to do stuff in 3D. It's really amazing, works great. So I'm going to segue and do a little bit of a short demo on that.

But before I do that, if you need to create spirals, threads, anything like that, I use the helix command. It's 2D or 3D. And these are things to watch out for going back to BOUNDARY, which I'm going to demo now. Make sure that boundaries are closed. They can't be off screen. There's sort of a bug in AutoCAD. And I think we fixed most of it, I haven't tested it lately, but we're aware of this. If something is off screen, also if a boundary is super complex, AutoCAD will just go, like, I don't get it.

So what I do is I push AutoCAD. I try to break it. And I created a curb system. And it was very complex, and it was all over the place. It branched, and came together, and all that other stuff. And what I found was it worked better if I just broke it up into sections. I can always join them

together later. So that's just a couple of caveats.

So let me give you a quick demo. I'll have to switch glasses. My number two son one time said, dad, are these the glasses you used to find your other glasses? Brutal. OK, so I'm just going to create some bizarre geometry, and I'm going to make sure it doesn't intersect. Intersect a point, that is. All right, boundary commit. I'm going to type everything in, because I normally do that and I don't mess around too much with the UI. Let's see here, try again.

OK, so I get this dialog box. It gives me a choice between two entity types. For now, let's just leave it at polyline. Regions are pretty neat, and if we have time I'll show you what you can do with regions. So you do pick points. You come inside here and you click, and end the command. And you don't see any difference. But is that cool, or what? That works. I use it all the time.

Now, if part of this is a big thin long thing, and it's off screen, AutoCAD, to make itself faster, will just consider things in the immediate neighborhood. And that's why sometimes they'll get screwed up. So if you get an error message and it says boundary couldn't be determined, one of the reasons is, maybe the boundary couldn't be determined. Maybe there's a gap somewhere. That's possible. Or if it's really off screen. So just be aware that if you see that error message, that's what you need to do about it. But I use this all the time, I recommend it.

Other things that I use all the time. I'm trying to be modern here. What I really use is I use the [? disk ?] command here, but measured geometry gives you areas and some other things. That's probably better. But I use ID to verify point locations. Primarily to figure out what the z value is. Because again, it's so easy to be fooled.

OK, here's a tip. Pretend that you're a blind spider creating a web. So you have to be very careful, you have to be very logical and say, OK, now this piece has to be halfway here. Did I really snap on this, or did I just think I snapped on it? Things like that. And of course, as you know, even with 2D geometry, if you make a mistake, that mistake can be repeated, or it can infect the rest of your drawing. It's sort of like a data virus in a way that can start permeating your drawing. So that's why I use ID for. I check my work. And even then sometimes.

OK, so measure geometry or distance to verify distances. And you say, well, tell me what the distance here is? Wait a minute, that's not right. Where did I make a mistake? It's easy to do. OK, properties, I use that a lot. There's some properties that you can deal with.

Grouping and ungrouping. So Autodesk Inventor is primarily oriented to mechanical engineering jobs, and built into that are assemblies and subassemblies. It's sort of integrated into the product. AutoCAD is more general purpose tool. You can use it for almost anything. So we don't really have assemblies and subassemblies.

So what I do is I use the GROUP and UNGROUP command to say, I don't want to block this together, because I have to explode it. But I just want to associate it temporarily. So it's very easy to group, pick some objects. Now it works as if you blocked them together. And then later on you can say ungroup this. And so you have the individual parts. That's how I handle those situations, group and ungroup.

How many are familiar with isolate and hide objects from the status bar here? OK, I use it all the time. I typically use hide, and I'll demonstrate this to you in just a minute. What this really is, they misnamed it. They should have called it the get out of my face command. Because that's what it does. It says, I don't care what layer it is, I don't want to know. I just want you out of my way. I want to temporarily hide this. And so you can make it go away, and then you can see what you need to see, and then you can unhide everything and it all comes back. So it's very, very easy, It's very direct. You just pick something and you say go away for now.

So let me give you a quick demo of that. Oh, here it is. Yeah, this is my first project. No, I'm kidding. OK so this is probably done in Plant 3D. All right, so I'm going to go down here and I'm going to get rid of this bubble. Everybody complains about that, we realize that at Autodesk, yes. So I'm going to say hide objects. I can either isolate them-- which says, show me just that one and everything else disappear-- or I can say hide objects which I just clicked. I'm going to pick this section of pipe and it disappears. And then I can look and see what's going on behind it. That's the whole idea, and I use this all the time. When you're done with that, you just go back here and you say, I'd like to end object isolation, and everything comes back. So I use this all the time.

Let me see something here. This is really interesting here. Oh, lookee there. Does that look right to you? Oh my. I think we have a problem here, don't we? A little bit of interference. It's easy to make mistakes. I was sort of glad to see that. I said, oh, I'm not the only one that makes mistakes. All right.

Viewing in 3D. And I showed you a 3D view, but let's start from scratch. The command that I use is called 3DORBIT. And this is what it allows me to do. It allows me to specify whether I

want orthographic projection or perspective. I can set visual styles, colors here. I'm to have to show you that. And then there's a shortcut which I'm going to show you next.

So let me go back, I'm going to get a demo what I'm talking about. So this is a kitchen remodel that I did many years ago. And that probably looks familiar to you as sort of a plan view. Now what I can do is I can enter 3D orbit-- 3DO shortcut. And then with my left mouse button, I just press and drag. And so you can see that I have parallax, I can get lots of different views from here. I can see what's going on.

Here's a trick. You right click. You go down here and say, I'd like to see this in perspective now. Oh, now it looks a little bit better. Generally I work in an orthographic projection. I'll tell you why. Reason number one is performance. I get some better performance in orthographic projections. Number two, a lot of the work you do in 3D you want to do visual checks. And so with an orthographic projection, you can line up things and you can see. If something is sticking out and it shouldn't be, you can see it right away. So that's why I do it. Looks a little bit odd, but you get used to it.

Number two is there are two conventions within computer aided design for what is considered the top or plan view. There are two different conventions. And when I first came to Autodesk, this really messed me up for a while. In mechanical design, the x-y plane is your front view, right? In architectural drawing, the x-y plane is your plan view, or your top view. AutoCAD, in its fuzzy little heart, uses the architectural convention. So you can save yourself a lot of grief by just doing it that way. Just a tip for you that are oriented for mechanical engineering.

Let's try some of these things out and see what happens. I said it was a kitchen remodel, so I'm going to exit this for now, and I'm going to-- let's see, lots and lots of layers. I'm going to turn on a pantry. We have lots of kids at the time. So this was the pantry, but it was not enough. So we made this into a linen closet from the back side, and we put in a real pantry. And we put in a peninsula. And so this is what it looks like.

Now you think, wow, that's a pretty cool x-ray view of that. Well in 3D orbit, I have a bunch of things called visual styles. So for example, I can do a 3D hidden. Well, that looks terrible. Let me take a look at 3D wireframe. OK, well, that's sort of like old technology. But it does allow me to see through things and conveniently snap to things behind things. So that's another tip for you.

Conceptual, probably most of our customers that use 3D will do the drawing using the

conceptual visual style. But there's others. Let me show you what the others look like. And you play with this when you get back, it's a lot of fun. There's a hidden style, which is cool. You can get a realistic thing here. Shaded it is kind of interesting. Shaded with lines is even better, I think. Shaded with edges.

Continuing on, a couple more. This was a nice one, let's skip a couple. Sketchy. Is that cool or what? Look at that. There are architects that that actually will create a 3D model, and they'll use that as an underlay, and they will hand draw over that. So they get a hand-drawn look plus the assurance that what they're actually doing is correct. And they get all of the perspectives and everything correct. So that's another of the tricks some people use. But you can use the sketchy visual style.

And then I showed you right at the beginning the x-ray kind. Which is convenient, because you can get a little bit more information that way. So you can change it. Now, there's another way of changing it. Way up here, which sometimes isn't the correct color, you can click this and you have all of your visual styles available. Let me go back here. I'm going to save that for later. Changed my mind.

All right, how do I get back? I've been doing all of this stuff. I've had a lot of good times, but now I want to see a plan view. How do I get to a plan view? OK, trick question. The command is plan. So I'm going to enter plan, and there it is, done. OK, so I've given you two commands so far, two out of the 10. 3DORBIT, plan. I use them all the time.

Oh, I know what I want to do. Get rid of this. OK, I need to cover background colors and then a quick way of getting different views. So the background colors, if I go into Options, and if I go into Display Options and then Colors, you'll notice that like in a 3D parallel projection or 3D perspective projection, I can control various colors, background colors, and everything. I've got it set to white here.

But if you ever see a background, you say, I don't want to have a black background or gray background, this is what you do. You go into the Options, Colors, Display tab here, and then Colors. And then you can go through whatever projection you're using and you can set the background colors this way.

And then if I want a very quick way to get a 3D view, this is just a short cut. What I can do is I can press Shift, the middle mouse button, and drag. And that allows me to not have to go to 3D orbit, but it doesn't give me as many options. So how do I get back? Plan. OK, that's your

first two commands. That was easy, I hope. Very easy.

By the way, one other thing I should mention is that the Plan command goes to the x-y plane of your current UCS. So I told you UCS is important. This is one of the things that it does. So if I shifted my UCS and flipped it on end or something and I said plan, that would be the plan view then. So if I went to look at a front face, that's a easy way of doing it. I shift the UCS and just use plan.

Speaking of the UCS, what is it? I think you know what it is. What's it for? It gives you construction planes. When you create a circle, you give it a center point and a radius, right? But a center point and a radius, doesn't that define a sphere? Well what AutoCAD does is, it says, I assume you're probably going to want to create a circle. And so it will create a circle in whatever plane that is parallel to the x-y plane of the current UCS. So if you change the plane of the UCS, you can orient circles. I'm going to demonstrate this in just a minute, but that's one of the things that UCS is for, is to define a construction plane.

It will also define orthogonal directions. You're all using F8 to get your ortho mode on, right? So you can change that by changing the UCS. Now you have new orthogonal directions you can lock into. And then finally, and very importantly, the z-axis serves as a default rotation axis. So if you ever want to rotate something, you change the UCS so that z-axis defines the axis of rotation. It's the hinge. So if you want to swing a door or something like that in 3D, you make the z-axis go along the hinge, and then your rotate command will work. So I'm going to demonstrate this on a wireframe model-- what's the kinds of things that you can do.

Another tip is there is a setting in AutoCAD, which is called dynamic UCS. If you have a solid model and you're moving your mouse over surfaces, it'll automatically shift the UCS onto that plane. This can be useful. I usually turn it off. Because it's really critical that you know where the UCS is. And if you're a little bit off, you can introduce error. So I have to be very methodical, and I just hit an F6, I turn that off, and then it doesn't change. It's whatever I set it to, I can do whatever I want, it's not going to change. This is just how I work.

So there are three options that I'm going to demonstrate for you in the UCS command. And I'm going to do a jungle gym here and show you how that works. First of all, let's say I want to create a circle. I create C for circle, and the circle is in the x-y plane. You can see this x-y plane here.

OK, so what if I want the circle here to be on this plane here? OK, watch. I enter UCS, one, two, and then a point on the x-y plane. It could be here, could be here, midpoint, doesn't matter. Now the x-y plane, my construction plane, is located here. I'm going to add some geometry to make sure I don't make any mistakes, like that. I'm going to enter a circle. I'm going to specify a midpoint of this line right here, and it snapped here. But now let's make sure that I'm in the right place. Yes, it's in the correct plane.

So when you get back and you start practicing with this put UCS orientations on all kinds of planes just to get comfortable with it. So here's another circle. I'm going to put a little circle right here. I move it around so you can see that it is, indeed, in the correct plane. It's easy to get fooled. One more thing. I mentioned that z-axis UCS ZA for z-axis. I put a point here, I put a point here.

The z-axis is now running along this line. If I enter the rotate command and I pick my swing here, and here's where I want it to rotate, I can swing it like this. You follow me? So if it's doors or whatever you need to rotate, make this a UCS z-axis, and now you have an axis of rotation. OK, how do I get back? UCS is sitting up there. I don't want it up there, please come down. I say UCS, Enter, Enter. And now it is coincident with the world coordinate system. You're back home again.

So that's the third command, UCS. But I know what you're thinking. You're thinking, but what about this icon here? It's in color. My UCS icon is not in color. OK, so with 3D visual styles, you can tell you're in a 3D visual style because the UCS icon is in a color. And if you're in the 2D wireframe visual style, it'll be just like you've seen it before, just like lines.

Another thing is maybe you want to take an image of that and you don't want that to show up there. So here's the next command. This is the command number four is UCS icon. This specifically controls the icon. I have some options. I might want to turn it off. I would turn it off in the case where I'm taking an image, or I just want it out of my face for some reason. But when I'm actually working, I always have it turned on, and I always have it displaying at the origin point. That's another option. You can tuck the UCS down here if you want, the UCS icon, I don't do that. I want to see really where it's at.

OK, let's take another look. I think there's one other point I wanted to mention. No, I've got that. OK, so we have the essential options. UCS directly at the command prompt to return it. That's good. UCS icon, off for screen shots, on and origin for modeling. Here is your 2D

wireframe representation. Here is what it looks like in 3D visual styles. VS is visual styles.

Profile operations. Now we're getting into some of the meat of this. So the first profile operation is the EXTRUDE command. So remember the trick I showed you with boundary? You can create a boundary, and you can extrude things directly from that boundary.

I use the EXTRUDE command because there are several other options that sometimes I like to use as well. Like for example, I could create a frustum. I can change the size of the extrusion, I can specify a path. There's some other options. Some people in previous classes asked me, why didn't you talk about PRESSPULL? Well, this will do everything PRESSPULL can do, and some additional things. So why even bring it up?

So let me give you a demo of that. We're back to this. I'm just going to go wild and crazy. So I've got this profile here. I'm going to put it in a different color just to make it a little more visible. What am I doing here? Oh. For now, let me do this right. That's not what I wanted to do. Try again.

So I'm going to say UCS, z-axis. I give it two points, my z-axis is running along here. I'm going to enter the rotate command, pick the profile, pick this point. And now I can rotate this around the axis. So I'm going to say I'd like to rotate this, the z-axis is going that way, and so the positive angle is going to be toward me. So I'm going to say negative 90. It's the right hand rule. And now I'm going to change my color, and I'm going to say extrude this. And I'm going to change my visual style, I'm going to pick maybe shaded with edges, and there it is. My first 3D part here in the class.

So I can take any profile that I've generated and I can extrude it. I can take that profile, flip it up on end if I need to. Like drafting the glass box, I can flip it in any direction or just have to go straight up, extrude. That's your first profile operation. There's two more. Just going to clear this.

When I work in 3D-- this is another tip-- I work almost exclusively in an isometric view in whatever convenient view I have. I move it around until it's unambiguous. I find that if I work in orthographic views, it's so easy to snap to the wrong thing, or get confused. So almost exclusively in some kind of an isometric view.

All right, so the next one is revolve. I've got a couple of cute things. The best thing I can do is just demonstrate it for you. Oops, I want to open. Let's do glass, I like the glass. So what I do

is, these are individual objects. What I did was I used the boundary command and then I flipped this thing up.

Now, the UCS, I'd like to do a z-axis. I'm going to pick this point and that point. UCS icon, origin. There we go, I like to make sure that it's at the origin. And now I'm going to check my color, sort of a light gray, that's fine. And I'm going to say revolve, or just rev. Pick the profile, pick the point. I've always wanted to do this. If somebody says, I'd like just a half a glass of wine.

Now let me pick a different visual style. I want to print this out so bad. OK, so let me see. Let's do shaded. Well, that doesn't look very convincing, so watch this. Remember, I like to use the Properties command. I'm going to pick this object, and I've got a bunch of things I can change. I can change the color, and layer, and la la la. And then I get to transparency.

So transparency is like color. I can set it on a per-object basis. I can also set up by a layer. I can say everything on this layer I went to have a certain level of transparency. I can set it by object. I'm going to do that now. So how transparent? How about 80% transparent? And now let's do 3D orbit. I'm going to spin this around, and it's reasonably convincing, right? That's pretty good. OK, all right.

So that's the first example of using the revolve command. I'm going to give you one more example of the revolve command. All right, let's see here. OK, this right here is a section of a bike rim. And what I'm going to do is I'm going to use the revolve command. I'm going to pick this profile, pick two points to give it an axis of rotation, and I'm going to change the visual style to maybe shaded. And there it is. So the axis of revolution, like a bicycle wheel, can be in a different location. And that would be an example of how you would use that. Would be a tool.

OK, and the third and last of the profile operation is sweep, and this is really cool. So I already mentioned why I used 2D polylines, and then I need to sweep a profile. So I'm going to bring up this drawing and demo that for you, how that works. All right, so I've got this chair. I'm going to go in here and I'm going to pick this tubing here and delete it because I want to create a different kind of support here. So watch what I do.

Step one, I go to a reference layer which I have turned off. I strongly recommend, when you're generating things in 3D, create at least one reference layer. Why? Because you will always go back to that reference layer-- I guarantee it-- because you want to regenerate some of your

geometry. You can modify solid objects and AutoCAD, but I'd say 80% of the time it's faster just to go back to the defining geometry and regenerate it. That's just my experience.

So let's try the sweep command. Now, what layer am I on? I'm on the frame layer. Yeah, that's the correct layer. So always be checking what layer you're on. I often make that mistake. And I'm going to enter sweep. Now I need to pick a profile. And I do have the original profile here. But just to show you that it doesn't has to be actually on the object, I'm going to pick this right here, this square as the objects to sweep. It's a little tricky here. Pick it first, and then I pick the path second. What do you think you're going to see? Bang, there it is.

So if you're doing any sort of piping, or railing, or chairs, that's the way that you would want to use it. You want to use it with 2D polylines, typically they're going to be filleted, right? And so that's why you want to use that. If all you want to do is you just want to have a path that goes in 3D and make sure it's all connected, then 3D poly's the way to go. But you can't fillet it right now.

All right, well that's pretty cool. And again, all these drawings are yours. So paths when I'm going to sweep. And oh, this is important. There is a system variable called delete object. And normally it's set on, I believe. Where after you sweep, or after you extrude, or whatever operation you do, it says, delete the defining geometry, the profile.

I never delete it. I always make sure that I keep it, because what if I want to change the profile? Oh this has got to be like an inch shorter over here. Well, I go back to the profile, make it an inch shorter in 2D-- a lot of my 3D stuff is just done in 2D. I shorten that, and then I regenerate it. Boom, I'm done. It's easy. That's what I do. So set that to keep your reference geometry. Distinctive colors, this is sort of obvious.

Boolean operations. All right, so we have three Boolean operations I'm going to show you. So the first one is union. Joining solids that you've created. Now, I'm going to show you from an actual project from an actual home which I actually live in. So let's take a look at this guy here, get rid of him.

This is the front yard of my house. We have expansive soils, and so the front sidewalk got all screwed up and everything. So what I decided to do is replace the walkway and the driveway with something that wasn't really cracked all over the place, and was a little bit nicer and swoopier. So after driving my wife crazy with all of my designs and redesigns, I finally came up with the following. And by the way, this is all 2D. Each one of these things is lines.

So I'm going to take you through my operation. This is what I actually did. So I'm going to turn off the old walk, I'm going to turn on the new walk, what I came up with. And ooh, cool. So the first thing that I did was the following. 3D orbit, I turned perspective on because I wanted to see what this looked like in perspective. And so I actually widen this a little bit so it wouldn't look like it was like pinching closed. So that's the first thing I did. Later on I laid it out with a hose. How do I get back? The plan command.

All right that's the first thing that I did. Oh, you know what I'm going to do next is this. So I want to find out how much concrete I need. So this is what I did. Is I have this on a reference layer here, and I'm going to go on a 3D solid layer. I'm going to use the boundary command. I've got to set the polyline. I pick a point here, and now this is a boundary. And then I'm going to repeat the command, pick a point for the walkway, and this is a boundary here.

And now you do something here. OK, so you can see the boundaries are generated. Now I'm going to extrude these. Now, the driveway, I made that extrusion five inches. So I just pull this down, and I enter-- this model's in inches, so five. And the walkway didn't have to be as thick, so I'm going to pull-- ooh, boy, I've never seen that happen. That was weird.

OK, so extrude. And I'm just going to pull this down enough, and then I'm going to say, three inches. Now I'm going to union these together. I'm going to change the visual style to maybe shaded with edges. So you can see what I've done. This is one object here.

So how much concrete do I need to order? This is a bonus command, mass properties. I pick this and it tells me I need 483,000 and change cubic inches, thank you. So what I'm going to do is this. Is a quick calculator. Because I didn't remember it, I'm going to go back here and pick up my cubic inches and paste it into here, and divide it by 144 divided by 12 equals that many cubic feet divided by 3 times 3 times 3 is 27 cubic feet per cubic yard.

So I needed about 11 cubic yards. It came out about 12, the estimator ordered I think 13 or 14. But it works. This is how it works. So you saw what I actually did and applying the union command, combined objects together. OK, that's the first of the three. Let's take a look at the second of the three.

OK, this second one is the subtract command. I use subtract and intersect probably more than union, and that's why I put stars by them. But let's take a look at this model. This is a model of the foil point used in the sport of fencing. And so what I wanted to do, because I did some

armoring for the sport of fencing, I wanted to teach people.

So how did I create this? Let's take this apart and let's see how I created this. So here's the model, and I'm going to take it apart. And we're going to take a closer look at this. Now this is a group right here. Let's zoom in on this. I associated this together as a group. I'm going to ungroup these, and now I can move the individual components. Do this right. Just to add a little bit of fun. And these are the components for that foil point.

Now, how do I create this well first of all, I created a barrel. And you can see, I probably created a cross section and then revolved it. So even though it looks complicated, it's just little small operations. You're thinking about the threads. How do I do the threads? I created a helix, I created a triangular profile, and then I used the extrude command. There's an extrude where I profile and sweep it along the path with maintaining its orientation. So it rotates along with the helix. And so I created a spring-like object which I subtracted from the barrel, and that's how I got my threads.

But that brings up another question is, how detailed do you want to make this model? For my purposes, I just wanted to make it realistic looking so I could then point to things. I can say, OK, so when you're doing armoring, here's what you need to watch out for, and stuff.

So another thing you might be wondering is, what about this quarter section I pulled out? Well, there is a section command in AutoCAD, but what I did was I just created a rectangular box shape and I subtracted it out. It was sort of destructive thing. Because that's what I wanted to have done, is I just wanted to show a section removed. And so I did a subtraction.

Now, this is fun too. Putting it back together again. And I'm going to show you one other thing. I'm going to pick this object here, I'm going to enter Properties, and the transparency I'm going to set it to maybe 70% for this one. I did pick it, didn't I? Try again. 70, and just show you what that looks like. It's kind of cool, I think. So you can sort of partially see through things, and see what it looks like on the inside. All right, so I use subtraction all the time. That's an example of something that looks complicated, but it's actually composed of simple parts.

OK, intersections. This is a powerful command. It's really amazing what you can do with intersections. So imagine going back to your drafting training, imagine the glass box. Imagine the profiles that you see in each view. Imagine extruding the profiles through each other and then doing an intersection. In one command you will get the envelope of the part. I'm going to demonstrate that, it's really amazing. This is what I'm going to demonstrate.

OK, again, I'm starting from a simple 2D drawing. These are separate objects. So the first thing I want to do is, let's see what layers I've got. I've got front and top, and that's what these objects are. I've got a reference layer, which is current. I always check that. When I do extrusions, I'm going to do it on a solid layer, so here goes.

The command is boundary again. Pick a point. OK, so there's my first boundary. Cool, that was easy.

For the second one, I'm going to do a little bit of a trick. And I told you right at the beginning that there's something called regions. I'm going to show you a 2D version of 3D solid modeling. Watch this. I'm going to enter the boundary command. But this time, I'm going to specify a region. This is all bonus for you. Region, pick a point, and I'm going to pick this point right here. It converts these things right here into region objects. Now what can I do with a region object? I can use the Subtract command. If I spell it right.

So from this region, Enter, I'm going to subtract this, and this, and this from it. Now when I hover over this, the whole thing is one region. So if I have something complex, I'll do a region, do my Boolean operations, and now what I'm going to do? I'm going to extrude it in its entirety. That's what I did with that bike frame thing, the wheel.

OK, so here goes. Get into some kind of an isometric view. I'm going to go ahead here, I'm going to turn off the top and front layers. Use layers a lot. Oh, there's one other thing I need to do. I need to set my UCS z-axis. K a point here and a point here. The z-axis is pointing in that direction, positive z-axis. My fingers are curling in the positive direction of rotation. So that's how I can tell.

So I'm going to enter the rotate command, rotate this profile, enter around that point. And then I can use the ortho mode to just snap this, or I can give it a negative 90 degrees. Either way will work. I'll do it this way. Now I'm set. So I'm going to extrude this how far? Doesn't matter, far enough. I'm going to extrude this, how far? Just through the other one. I do want to be on the 3D solid layer. Because if I do an intersection now, and I pick these two objects, I get this particular model.

Now, let me go ahead and do a couple of things. I'm going to turn off the reference layer-- oh, I put it on the reference layer. I hate it when I do this. All right, it's easy. I'm just going to undo

a couple of operations. I'm glad you see this, because I do this all the time. Make sure I'm on the correct layer here, 3D solid, and now extrude this, extrude this. Intersection between these guys. I'm going to turn off my reference layer.

Now what do I have? I'm going to put myself into maybe just a regular shaded visual style. In fact, I'm going to do 3D orbit because I'm going to put myself in perspective mode. I right click to get this perspective mode. And now you can see, I did this in one operation. I just took two profiles, and in one operation, boom, I got that. How hard is that? It's just fun. It really is.

OK, let's do something else. This is an old fashioned [? bow site, ?] but some of you don't do [? bow sites. ?] Some of you do architecture. Here's a way you can use the same technique to create a hip roof. I give you a demo of that.

OK, so here's the model. These are profiles. OK, that was easy, and I just already flipped them up. If I do an extrude this way, extrude that way, intersection of this and this. And I get the hip roof, there it is. How hard is that? That fun? It's really easy. You start using these tools, putting them together. And before you know it, you can really confuse yourself.

So quick review. Viewing commands, 3DORBIT and PLAN, right? UCS commands, there are two of them. What are they? UCS and UCSICON to control the icon. OK, that's four commands. We have three profile operations. EXTRUDE, SWEEP and REVOLVE. OK, we have three Boolean operations, UNION, SUBTRACT, INTERSECT.

There's more than this. But with this you can create the majority of things that you need. And then when you want to say, oh, well, but I've got a curvy surface that I'd like to loft, yeah, there's a loft command. I would like to find interferences to locate potential-- yeah, there's the interfere command and stuff. I'm going to share a few of those just sort of as a bonus.

OK, here's one. This is extruding in three directions. So I have three profiles, move them into place rotate them, and pass them through each other. And then in one intersection operation, I was able to get this. So I have this view, and this view, and that view. Intersecting them through each other, gives me that envelope in one part. Let's take a look at a couple of others, and I'm to give you some tips.

OK, this is a project that one of my sons and I got into in the sport of fencing. This is a circuit board, and what was I interested in? Well, I'll show you what the front looks like. It looks like

that. This is used for electronics scoring the sport of fencing. But let me go ahead and use my hide objects. I'm just going to hide what's interfering here.

I have these standoffs. I had to have these standoffs because I found that after I modeled it, the LEDs that were sticking out on the other side of the board were actually touching and pushing against the label. And so I said, oh, before I do anything else, I'll need to have some standoffs. And I found some quarter inch standoffs, and then it pulled the board away from the label on the other side. So you can avoid expensive mistakes in that case.

So how did I create this box? I mean, this looks like a cool box. It is a real commercial box. It's got a draft angle, three or five degrees, or whatever it is, something like that. How do I generate that? Well, you can see a lot of subtractions but how do I get this box shape? Well, let me show you something that I did before I got to the point that I'm at.

OK, I had these profiles, I had an inner box and an outer box. The inner box is the inner volume, and I crossed the two and found an intersection. That gave me the 3D part. The outer box, the outer shell did the same thing. I took the outer shell as you can see here, and then I subtracted the inner volume from the outer volume. And then the last thing I did was I added fillets.

One of my tips is, if you have fillets and chamfers do it at the very, very end. Why? Because all of a sudden you say, well actually, I need to add this hole here, and it needs to be exactly so many centimeters, or so many inches from this corner. But I don't have a sharp corner anymore. Oh, rats. So it'll save you a lot of work.

OK, let me give you some tips, and I'm going to show you a few other drawings. OK, these are my best practices and advice that I'd like to give you. Number one, your first model shouldn't be the Taj Mahal. Start simple till you get comfortable with it. Number two, your visual complexity in a 3D model is an order of magnitude more than what you had in 2D drawings. You're going to have to use a lot more layers. So use them a lot. Because you want to keep stuff off the screen. You don't want to have everything hitting your eyeballs all at once.

And I use typically use layers for that. Create your profiles first, you've seen that. Move them into place, or rotate them into place. Keep the profile geometry, because later on you might want to change the profile. And then re-extrude it, or whatever you're doing.

Check and recheck distances and dimensions. Oh, it's so easy to make mistakes. And then

this one is interesting. Limit the detail to what is justified to your goals. I'm going to bring up two models, and let's see what you think about it. OK, my keyboard model. So I created two keyboards. This one right here on the left looks kind of clunky, doesn't it? But this one over here, a lot more detail. So my question is, which is the better model?

AUDIENCE: Depends on what you need it for.

DIETER SCHLAEPFER: Yep, you're absolutely right.

AUDIENCE: Because if you're just doing a desk, then first one works fine. But if you're modeling a keyboard, then the second one.

DIETER SCHLAEPFER: So you have somebody maybe that's an intern reporting to you, and they said, oh, I did the keyboard you wanted, I only spent four hours on it. That's not what we needed, we needed something just simple. Or maybe you do need this. Maybe you're going to do some stress analysis on this or something, I don't know. This is a model, this is not reality.

Now you do you can put a lot more detail in things that you want to impress people with. For example, if you're going in front of a planning commission, you can show something with a detailed, or eyes go, whoa, look at that. So you get some emotional involvement, that's great. The Boston Redevelopment Authority requires three solid models-- or at least did at one time-- to be submitted with every proposal. One of them was to be used with some kind of wind analysis, and for shadow studies. They had a coarse resolution, and a medium one, and then they had a fine resolution one. So again, it depends on what you're using it for.

Here's a similar one, same principle. OK, so how did I create these stairs? This one right here, I generated that profile and extruded it. Done, that was fast. This one right here, each one of these is an individual cut out part. Why would I do this? Well, maybe I need to cut out those parts. Or maybe I don't, in which case I just want a visual representation. So manage your complexity.

I already mentioned delaying filleting to preserve the sharp corners. The group command, I already mentioned that also. Creating blocks from repetitive objects to reduce drawing size. Autodesk every once in a while would get models from our customers. Maybe they have a problem with something, we'd like to see what they've done and debug it a little bit.

We got one model that was enormous structure, and it had all kinds of steel beams all over the place, hundreds of them. And what this customer did was they made blocks out of almost every one of those parts. Why do you suppose they did that?

AUDIENCE: [INAUDIBLE]

DIETER SCHLAEPFER: Yes, that's correct, and there's another reason.

AUDIENCE: Turn it on or off.

DIETER SCHLAEPFER: No.

AUDIENCE: [INAUDIBLE]

DIETER SCHLAEPFER: Yes, that's correct. Saves memory. The way that blocks are structured, if you have something really complex and you're repeating it many times, if you generate it as a block, it's written in the block's symbol table. And then every instance of that block just simply points to it. So every time you add more of them, you're just adding a few bytes to your drawing.

So I did an experiment. I started exploding them, and AutoCAD turned up its fuzzy little tummy and died at about 90 megabytes. I mean, I just wanted to see. So remember the model that I showed you at the beginning? When you see repetitive structures where you have the cross braces and stuff, I would put those in a block. And then you'd like rubber stamp them. You're assured that it's always correct, you're assured that not one piece is going to be moved out of place. Your saving memory. What could be better? So I would recommend that. Yes, sir?

AUDIENCE: What's the memory difference if you do that one structure and then you use an array, when I needed an array?

DIETER SCHLAEPFER: The array associates it. There's two kinds of arrays. There's associative and non-associative. It really doesn't matter. The array element, if it's a block, you'll still have the savings. Yeah. OK, so anything that's complicated, yeah, put it in a block if it's repetitive. That's my advice here.

OK, save a version of a model at each stage so you can revert. This is a really good thing that I almost never do, and I always regret. Dang, I wish I could go back three versions. So do that.

Landscaping. So I've tried experiments with creating landscaping. My recommendation is, go and buy some landscaping from somebody.

My best shot was to create an outline of a tree here, and then I just replicated it, like the little cutout things. And that worked out reasonably. I've got a model I can show you in a minute that uses that technique. Don't do this. I've seen some drawings, they've got a cylinder, and they've got a sphere on top. That's disturbing.

I've also seen models of people that look like Robby the Robot and stuff. Again, is that your idea, is to focus somebody's attention on those things? No. So what I've seen people do, and I love this, is to find images of people and to trace an outline of that. You can put outlines of people. Because your focus is on what's behind them. It just shows people for scale.

Or you can take this profile, extrude it a little bit, and give it a high level of transparency. So you get sort of like shadows of transparent people. So you get the idea of people without drawing attention to that person. So that would be my recommendation with that. How much time do we have?

AUDIENCE: [INAUDIBLE] at about 9:50.

DIETER SCHLAEPFER: OK, so we're getting pretty close now. All right, so let me give you an example. I learn things just by playing around. So let's take a look here. I'm looking for some trees somewhere. OK, so this is my best shot at a tree. And it's not unreasonable, it doesn't draw unnecessary attention to itself. But like I say, generally you probably want to buy landscaping.

What else do I have in this model? Oh, lookee the pretty cars. How do I make these? I use the three profiles. I drew a BMW or something, and just traced over a side view, a front view, and a top view, and extruded them through each other like I showed you. And oh, I had to add the wheels separately, but it didn't take me long. I made these into blocks, and then you can replicate them.

And so again, it's not supposed to draw attention to these things, but to represent them. Let me show you one more thing. Oh, guess what? Hip roof, look at that. I bet you know how I made that. Remember I told you about complex boundaries? I did these in parts, and then unioned them together because the boundary command was just too much for it. Oh, lookee the balloon. We have a lot of balloons in our area. So that was fun creating. I did it like sections of an orange to get the different colors and stuff. You just play around with it,

experiment with it, and try stuff. You learn stuff that way.

OK, so this is a model of part of the campus of a university near where we live. Let me see, I think there's some other tips that I was going to show you a few more models, and then let's see if we have any questions.

This is a 2D drawing of a gate a designed using AutoCAD. This is flat, this is 2D. Let me show you the next version of this one. You see where I'm going with this? OK, you can ask the intersection command more than it can do. Because if you just extruded these and intersected them, there'd be some ambiguous areas, that little blobs that show up. So in that case, I did this by the parts, and here's what it looked like when I was done.

And so this is probably sitting in my backyard. Remember I told you about mistakes? Oops, that should go a little bit farther here. I just discovered that last night while you were partying. All right, there's a few other tips I want to give you and then we'll have some questions.

OK, so next steps. Everything I presented to you is yours to use. You have it by downloading it. You can go back over the presentation. There's 24 of the models are there for you to use. Create simple things. I mentioned a further study, please do that. Look at your class notes at the very end. I've got lists of commands that you can investigate. And for example, like in my kitchen, you might say, well, what does it really look like on the inside? And so you might use the 3D Walk command, and there's probably some better tools nowadays that are available to look.

Or maybe you're interested in 3D Studio Max or something, and import that. Or generate models. Here's a tip for you. If you create an architectural model in 3D, extrude it. And let's say you want to 3D print a model of that. Here's a computation you want to be careful about. In that scale, how thick is your thinnest wall? Because your 3D printer can print things reliably only so thin, right? So you can either make the model bigger or you can artificially fatten some of the thinner elements in that. But yeah, why not print some of these things?

And then explore. I usually don't use the interface, but I do want to show you just a couple more things here before we're done. I'm going to show you another one. Interference, let me see. Ah, here it is.

OK, this is an actual model of a mechanical room from a school. I want to hide a wall. So

guess what I'm going to do? I'm going to say, hide that wall. And there's an interfere command within AutoCAD where I can do something like this. Interfere, I pick this guy right here, and I pick this one right here. And it shows me that there is an interference. So there's a bunch more tools that I haven't shown you, but they may not be relevant to what you're doing. So that's why I put all this stuff in your class notes.

So my objectives were to take you from you were in 2D, and to show you 10 commands that you would need that are pretty easy that you can use to ramp yourself up into 3D. So I'm hoping I achieved that objective. Any questions? Yes sir.

AUDIENCE: Do you got any quick tips, tricks for using the resolve base command. I've had some trouble with that [INAUDIBLE].

DIETER SCHLAEPFER: I would say that make sure that your profile really is 2D, and that it is where you think it is.

AUDIENCE: Sorry, I misspoke. Just rotate the base.

DIETER SCHLAEPFER: Oh, rotate the base? Now, if your z-axis, let's say, pointing up, it's pointing up everywhere. But to be extra certain, I sort of always-- yeah, I'm paranoid. So I put it directly on an edge. And then I look at it in a view, and if something looks disturbing, or bad, or something, then I recheck my points of the axis, yeah.

AUDIENCE: Just as a corollary to that, sometimes I want to rotate that face, I'm giving it degrees, but [INAUDIBLE]

DIETER SCHLAEPFER: So z-axis, positive angle is this way, negative angle's that way. We can talk about it a little bit further at the answer bar or something. You can bring up a drawing. You had a question?

AUDIENCE: You recommended show solid history when it comes to [INAUDIBLE].

DIETER SCHLAEPFER: Solid history will retain all of the individual components that were made when you subtracted, or unioned, or intersected. And so if you need to take a portion of a model and to move that, solid history would come in handy. I don't usually use that. I usually keep the profiles. But it sort of depends on your application. You could do that. Solid history, solid hist would be one of the commands, yeah. Other questions? Yes sir?

AUDIENCE: When did you want to do this [INAUDIBLE].

DIETER SCHLAEPFER: So if you union something, you glue it together semi-permanently, unless you have solid history on. I mean, it is like really glued together. If you block something, you can explode the block. Group is block light. So if you plan to have assemblies and subassemblies, I would group them. If maybe it's a furniture arrangement that you know is cookie cutter, I'd make it a block. Other questions? OK, you think I achieved the objective?

[APPLAUSE]

All right, good.