GEORGE MAESTRI: How is everybody today?

AUDIENCE: Good.

GEORGE MAESTRI: Good. As you can see, my name's George Maestri. I'm a staff author for, now, LinkedIn Learning. You may know me from Lynda.com.

And today we're going to talk about the principles of animation for visualization, architecture, and design. But basically this is a principles of animation course. My background is character animation. I started late '80s, early '90s, grew up with CG.

And there are a lot of basic principles of animation that apply to anything you do. And so we can always get kind of wrapped up in all the buttons and all the technology, but we always have to come back to fundamentals. It always has to be a good drawing, always has to be a good composition. And with animation it has to move well and it has to be appealing to the eye.

So we're going to go through a lot of that. I'm going to go through some theory. Here, let's go through some of this. Course is going to show all of you guys how to make better, more appealing animations. And then we're going to go through, basically, four major sections. We're going to talk a little bit about composition design. We're going to talk about the principles of motion. And then we're going to get into software. We're going to do a little bit of animation workflow.

Now, I'm going to be using Maya, but anything I do is completely applicable to 3ds Max or any other piece of software that you use-- I'm just going to be doing keys and animation curves, nothing really fancy, but just so that you understand some animation workflow. And then I'm going to talk just a little bit about rigging, because I think rigging is very important to the animation process.

Now before I go too far, how many people here would consider themselves animators? A few. OK, good, because this course is mostly for those people who need to animate and need to have a little bit of stuff. So if you're an animator, follow along. Hopefully I can give you some information that you haven't known before. By the end of this class, you should be able to do

all of this stuff-- understanding how images and composition, basic principle of motion, animation workflows, and a little bit about rigging.

So let's start off with a little bit of definition. What is animation? Well, it's basically just the process of creating the illusion of motion and change through the rapid display of static images. A lot of people call it the illusion of life, but sometimes we're not animating things that are alive. Good animation tells an engaging story. It's about storytelling.

And every time you have a question about animation, it's always good to come back to the question, what story am I trying to tell and how can I best tell that story? And the story could be an epic three-act drama over a two hour feature film or it could be, I need to show people why this product is really cool. It can be any sort of story you want but, again, you have to keep in mind what is the story that you're telling. And then, finally, I think animation needs to be visually appealing, because more visually appealing it is, the more it attracts the eye and the better it communicates.

So animation starts with still images. Now, I don't really want to get into, back when I was a kid, but-- back when I was a kid-- I started off animating cell animation. And we drew every single frame. We drew every single image.

I'm glad we don't have to do that nowadays, but one of the things it taught me was that every image is important. It'll you a couple of minutes to draw a frame of animation, it'll take you a couple of minutes to paint it, and you sit with those images for a while. And now we can blow keyframes through very quickly. A lot of times we don't step back to say-- OK, what's this still image mean, what is the importance of this image? So respect the frame.

OK, animation does start with the single frame. If you get the composition and layout right, the rest will follow and make your whole life a lot easier if you start with a good composition. So let's talk a little bit about composition/design, clear layouts, and how to tell a story. Now, I'm going to start off with just a really simple-- I'm going to jump out of this here. Going to go into Maya here.

And let's talk a little bit just about composition. Now, in a 3D app such as Maya or whatever software are you using it really is kind of a virtual environment. So everything starts with, where do you put the camera? So the story you're telling is, what's the viewpoint?

So if we have-- this is a really simple, simple, simple scene. Now, if you consider this, this is

kind of your vanishing point here at the center and this is your ground plane. Where does a camera go? What does that inform you about the story that we're going to tell?

Well, if we go really, really low, we have like a snail's eye view, kind of a low view looking up. OK, now that's going to tell a different story then something that's maybe at eye level. Or if we go a little bit higher-- something like that-- we start to go above the scene and start looking down, starting getting a bird's eye view. Or, if we want, we can even get the drone-size view, kind of the God view of the scene.

Now, each one of these will give you a different feel for your scene. So if all you're even doing is doing an architectural animation, and you're just doing a walk-through or a presentation of a building, where do you put that camera and what story and what information is that giving?

Now, I know this is just fundamental, but it is important.

Now, we don't have to just have this all centered either. If you want your vanishing points or your center of interest to be off to the side, that can give you another sort of feel. We can also angle it, give more of a cockeyed Batman in the villain's layer kind of view.

Now, as we start to think about this, we also need to start thinking about putting other things in the scene. So I've got a few things here. So let's go ahead and just put in a few characters here, or a few things.

So we've got some stuff in the scene here. And let's go ahead and just arrange that along there, just to give a sense of what a story might be. So if we have a story like this, where the ship is big and he's small, that gives a certain feel. OK, that composition is already telling a story before anything else moves in the scene. So when that first frame pops on the scene, your eye instantly recognizes a scenario, a scene, a viewpoint, a point of view, and it already is communicating to the audience before anything else moves.

And that's really important because a lot of times with animation you need your communication to be as clear as possible. So you want your set-ups, your layouts, and your compositions as clear as possible. You want to direct the viewer's eye towards what is important. And this is just a normal trick in film-making is basically what you're doing is you're kind of like the magician, and you're-- saying look over here, look over here, look at this, this is important. And you do that through a number of compositional, lighting, and animation techniques.

You could do another shot here or we could do another shot. OK, so let's take what we have

here and go a little bit further. So let's go back here-- I think I've got one more slide here.

So one of the things I also want to tell you is to guide the viewer. As an animator, you need to communicate what matters in the frame. Now, I've already talked about this a little bit, but we want to lead the eye to what's important.

Now let's take a look at this scene here. One of these exercises I like to do is just take a few simple objects, and try and create a story with it. Now, this is important because what we're trying to do is tell a story. So we've got some rocks. We've got a ground. And we've got a space ship and a little robot guy. And that's it. Now can we tell a story with this?

And this is a great exercise for you to do. Just take a couple of objects, align them with the camera, and just see if you can tell a story. So I've got just a couple of examples here. Some of them are probably pretty obvious, but right now everything's in a straight line. There's really no story being told. It's just kind of like a lineup. That's really nothing much of a story.

But if we move them, maybe there's a little bit more interest. We've got, now, the eye is kind of got this little bit of an arc here for the eye to follow. But let's go a little bit more.

OK, so now we're getting somewhere, because what we have here is we're actually telling the audience what's important. Bob, our little robot here, he's front and center. We're telling the audience, look at Bob. And then the spaceship is kind of off in the distance over his shoulder. That may be a story point. I'm not sure exactly what story we're telling here, but again this tends to force the user-- or the user-- the viewer-- my old computer skills here-- we tend to force the viewer to look at certain things.

Now, we can reverse that. And, again, I'm doing the ship over the camera. I've tilted the camera a little bit to give a sense of maybe this particular place isn't quite right. And again, this is telling a different story. This is a different story point than the previous one. And all we're doing is just moving stuff around.

OK, now we've got-- I'm the guy up on the rocks, looking down at the posse that's coming to get me, or something like that. And again, this is just another story point with the same objects.

OK, here's another one. Now when you start to arrange things in the scene, you need to also start taking a look at how things appear to the camera. So we need to take a look at things such as in line, composition, and things such as silhouetting. So I've got a little trick here I'm

going to do. And I'm just going to go ahead and change the materials on these characters, so all they do is look black.

Now, one of the things that you can do when you look at compositions and animation is take a look at it in silhouette, take a look at the black and white version of it. If you can tell what's going on from the silhouette then your action and your composition will be that much more clear.

So one of the things Walt Disney used to say is he said, keep things in the clear. So when Mickey Mouse would reach for something, he didn't reach directly in front of him, he reached off to the side, almost like how a magician works. And that's because that silhouette of the arm-- which you can see here-- is much more clear to the audience than something that's in front of a body.

But, you know, this is for character animation, but it also works for any other type of presentation. You want to make sure that what comes into the scene looks good in silhouette. If you're doing an architectural-- let's say you're doing a bathroom, and you're bringing in a faucet. You want to make sure that the faucet is arranged so that you can see the outline of the faucet and then bring it in. Don't bring it in at a weird angle where you can't tell what it is when you immediately look at it.

So again, silhouetting is really important. I'm on a laptop that's a little slow here, little bit of technical glitches here. So again, you can see the silhouetting of this really makes for a strong composition.

Let's go back to this. So, again, we want to take a look at depth, line, and contrast. Now, I want to show you just a few more examples that I have of this in more of a still-image sense here. So I've got some images here.

So the first one is just contrast. We want to have images that have contrast. Now, you can see that this has a very good silhouette of this person. We have some good contrasts. Now, this is a black and white image, but you can have contrast in color, right? So this yellow lemon pops against the limes because it has a color contrast.

Again, this is a really good example of contrast and also of line. You can see that we really know where to look in the scene.

OK, and again, this is a little more subtle, but again the contrast of that pop of color draws your

eye to a certain point in the scene. When you first look at that, your eye immediately goes to one place. And if you were animating something, that's where you would want the audience to look.

Now, we can also do depth. Depth is a really important factor as well. Depth of field is a great way to do that, if you have that in your rendering technology you can use that and you can use depth of field. Again, because this is blurred, the car stands out. A little bit more extreme here.

And then we also have things such as light and shadow. We are going to be rendering our images so make sure that the light and shadow draw you into the scene. Again, these are very strong examples of light and shadow. This scene here has a very strong vignette around the edges, which pushes you in as well as these lines-- these are basically just saying, look here.

And here is a more subtle version of that. Again, this is brighter so your eye is sent here. And here's another one again. This frames the action. And these make for great compositions.

And then also line. The lines in the scene can really draw your eye through the scene. So this fence draws you along the fence, makes you want to look where the fence is going just naturally. Another example of lines. Lines.

And, again, vanishing points make great points of interest. So again, this is just a really quick, quick overview. But the images that you start with are really going to inform your animation, so don't ignore those.

So now let's get into motion. So let's get into principles of motion. Now, a lot of people, when they talk about principle of motion, they talk about the 12 laws of animation or something like that. There was this book written by Frank and Ollie many years ago called *The Illusion of Life,* and they had 12 rules. A lot of those were also more geared towards cell animation. One of them was solid drawing, that sort of stuff.

But the basic principles of motion are all based on one thing-- physics. I actually majored in physics in college, so I know a little bit about it. But basically it's just physics. And when I actually came into animation, I was like-- oh, yeah, I get this, this is the laws of motion.

How many people have actually taken physics in college? Ah, more than one. OK, good.

And I found that that really informed me a lot of how things move. It's a really good base to start with. Now, all of these laws of motion have basically been boiled down into some rules of

thumb that most animators use to simulate the reality.

But you always have to remember that they're just rules of thumb, they're not-- you don't-- if there were actual laws that you just wanted to use physics, you could just turn on the physics engine in your animation software and be done with it. But you want to make it engaging to the audience. You want to time it so that it goes when you want it to go, not just when physics tells it to go.

So you can bend the laws. Basically what I'm saying is that they're are good rules of thumb, but you can always bend those laws. Animation is your interpretation of reality, not exactly reality itself.

So let's take a look at weight and mass. Now, the first thing we want to say is that in computer graphics no object has inherent mass-- it's just pixels or wire frames. And those by themselves are really just mathematical representations of a shape. They're not necessarily a car or a balloon disguised as a car-- we don't know because, until it moves, we don't have any sense of how much weight something has.

So as the animator, you determine how much weight something has by how you move it. So here's a really simple example. Let's go into Maya. So I'm going to go into this scene here.

OK, so I've got this scene, and its basically got some billiard balls or some spherical objects, actually-- we don't know if they're billiard balls because all they are is we will look at them, they're just wires, right? And if we shade them, they're colored wires. But until these move we have no idea what they are. So if I were to play this you see that that object is this one has basically more mass, this is heavier. This one's lighter.

And the only reason we know that is because when they connect and interact, the motion gives us a clue as to what's going on. We could have the exact same set up here and that's different, right? So in each one of these-- so just because we move the red ball differently-- all right, let's do that again. There we go. So just because that red ball moved differently, it seems to have different mass.

And so if we do this, you see that this object is basically solid. It has a lot more mass than this other ball. So how the objects interact will tell the audience how much mass they have and will tell you what the objects are made of. Are they they are foam balls or are they lead balls or whatever?

OK, so now we also need to talk about forces. Newton's laws of motion-- an object only moves when a force is applied. So force is mass times acceleration, et cetera, et cetera. Let's go ahead and talk a little bit about force.

Force creates motion here. So when an object is at rest it will stay at rest until it is acted upon by a force. So when that force acts upon the object, it accelerates it and moves it. And once the force is removed, the object will continue at a steady rate of speed until another force accelerates it along another axis.

So when a force acts on an object, it accelerates it. Now, this is just basic physics, but it's good to know. So it goes faster and faster and faster until the force is removed. And then it goes slower and slower. Or-- if you want to think about it-- faster, faster in the opposite direction.

And of course forces don't need to be opposing. You can certainly have an object moving in one direction and then have a force that comes tangential to the object, and that will go ahead and move that object in a separate direction.

Now, animator's liked to call this acceleration. They tend to call it what's called slow in and slow out. So when a force acts upon an object, its speed will slow into the motion. And so that's called slow in. And on the opposite side-- these are a little bit slow here-- but on the opposite side, we have the force gradually slowing it to a stop. And that's a slow out. So on the out side of the motion, we have a slow out, and we slow into the motion and slow out of the motion. So if an animator talks about slow in and slow out, that's what they're talking about.

Now, when we have forces acting upon objects, we're accelerating those objects in many different directions. And when we accelerate objects in different directions it naturally creates what are called arcs.

Now, natural motion-- when things move in the natural world, it's typically along an arc. Very rarely do we get one force acting on one object in one direction. We have things such as gravity, wind, friction-- all sorts of things that move objects not just in one direction, but in multiple directions. And these naturally form arcs.

So natural motion is usually along arcs. Multiple forces acting on an object will naturally create arcs. And then if you have an object in a rotation-based system such as the limb of a character, a robot arm, the limb of a tree-- they will also move along arcs.

So let's take a look at just some examples of arcs here. So probably the best example of arcs is throwing the ball. So if we were to-- actually this is off. So if we move it with one force, it moves a straight line. But if we add a second force, such as here, you'll see that it actually starts to carve out an arc. Now, that arc is because we have one force basically going into the action of a second force.

Now, we also have the ball falling along an arc here. And that's because we have the force of gravity pulling down. So when the ball goes forward, we have gravity pulling it down, we have the forward force of the toss, plus we have drag from things such as wind resistance.

Now, when we're working with objects that move in multiple dimensions, let's say we have an object moving along one dimension and then it turns into another dimension, you'll see that the animation curves also change. That's because it's decelerating in one dimension and accelerating in another.

And then, finally, we have natural motion such as the motion of the branch of a tree. Now this is because that branch is actually moving along an arc. So again, natural motion is along arcs.

Now, we also have things such as overlap and follow-through. So forces don't act upon a system all at one time. If I were to take somebody and grab them by the arm and pull them, that arm would come first and then the rest of their body would come later.

And we have a thing called overlap, which is a result of this. So if you have things in a system, some things will stop sooner than others, and some things will continue to move as parts of the system stop. This is called follow-through. So we have what's called overlap and follow-through, which is basically just force moving through a system.

So let's take a look at a scene here. OK, so typically this is called pendulum motion. So if I have a system here and I put a force onto the top of this, what's going to move first? Well, the top of the system will move. And the bottom of this system has weight, and so that weight will take longer for it to move. So as we pull that, you can see that that part of the system moves. And if we pull it in the opposite direction, we get kind of a pendulum effect.

And this is true in a lot of different parts of the world and nature. So you can see it in mechanical systems, but you also can see it in the floppy ears of a dog, how they kind of just move like a pendulum.

And a pendulum motion doesn't work just for this simple object. You can have even a more

complex object such as this chain. So what is this chain but just a stacked collection of pendulums, right? So you have a hinge here, and this is a pendulum. You have a hinge here, another. So we've got just a bunch of pendulums together and when this starts to move forward, you could see that this moves first, this moves next, next, next.

And so basically it's almost like a chain reaction through the system. And so what you start to do is you start to get this kind of waving like the grass in the field kind of effect, where you get this nice arc sort of effect. And so when you have systems like this, you have to take into account how the force moves through the system. So that's my theory.

So halfway through the course, we're halfway through the course. So that's good, we're on good time. So now let's take a look at how to apply some of this.

Now, I've got a character animation example here that kind of takes all of this-- so this basically takes all of the principles of animation and ties them into one little thing here. But we're going to do some simpler examples here, but I just wanted to show you how all of this kind of comes into effect here.

OK, so this is a little bit more-- so we've got overlap, follow-through. We have things such as anticipation-- which is more for characters, where you move left before you move right and so on.

So now let's go ahead and take a look at some workflow here. So when we animate, typically we start with keyframing. Now there are a number of ways to actually create animation. You can certainly do motion capture and procedural type of animation, but what we're talking about here is animator controlled animation. So we're going to start with keyframing.

Now, keyframing is basically the way that you would normally animate a scene. So what we do typically as animators, you'll take a scene, you will block it out. So you'll block out the major poses or positions of the things in the scene-- and that's called a blocking pass. And before that we do what's called a planning pass.

So we would have things such as storyboards, thumbnails, and all that sort of thing. We want to make sure that we understand exactly what we're animating before we do it. And then we block out the animation to make sure that things are in the right place at the right time. We hit our marks in what we do animation. And then once we get our blocking pass, then we can start to refine the animation and polish.

And so typically what you'll see in the animation workflow is you'll see probably two, three, four, or even more passes on it. So if I'm a director my animator will come to me, they'll show me his blocking pass, and then I'll approve that. Then they'll come back and they'll fill in all the main motion of the scene. And then when that gets approved, they come back and they move all the little tiny bits and make it all flow. And then they finally polish it and make the animation great.

So let's go ahead and just animate something and just kind of show you a little bit of workflow here. So let's do this little saucer here. Now have a simple rig for this saucer. There's basically just two controls-- there's one big control that moves it all, and then I have this control here which moves this up and down. And then I have this control here which lifts the legs. And that's it.

So let's go ahead and just do a real simple animation. We'll make this land. So first thing we need to do is understand how much time we're going to take for this. Well, let's go ahead and just do it-- I'm animating it I think 24 frames a second, so let's do about two and a half seconds. Let's go to frame 61, and that will be where it touches down.

So a lot of times I'll actually animate from the back forward. So I know it will be on the ground at 61, so I'll go ahead and set my key there. And then I'll go back, and move everything, and set a key there.

OK, now if we wanted it to, this could be our animation. I've seen a lot of people do that. They just bring it down, and that's it, and they're done, and they move on to the next thing. And that's not really animation. I mean, that's just kind of moving stuff around. It really doesn't tell us anything about the scene. It doesn't tell us anything about the weight of the spaceship. It doesn't tell us anything about the story. It's really just bringing the object in from above. If we wanted to add more weight, that would give us more information about this.

So one of the things about this is that this does have telescoping legs. So when this comes down not everything stops at once. So we have what's called overlap and follow-through-- the weight of the object will not all stop at once.

So as this touches down we can push this through the end, say I'm going forward about six frames here's-- five frames. In fact, let me go forward a little bit more here. And I'm pushing it down, so now it-- let's redo this.

So now this comes down a little bit. And then comes up. And then maybe settles down. So now we've got this coming down. Got a little bit of problem here. I think there's a problem with some animation curves here. So let's go through here, select both of these. Yeah.

So notice how these curves are a little bit different here. So what we're going to do is just go ahead and adjust this one. Sorry about this. There we go.

So now this is this comes down, and now this gives us a sense of weight. Now this is OK, I mean this is a little bit better. But let's go ahead and do something a little bit more interesting. Let's go ahead-- let's do a play blast of this so we can see what this looks like. So now this comes down. And it kind of bounces.

So this gives us a little bit more information about the weight of the spacecraft, but one of the things we could do is we could add a little bit more interest. We can make it hover before it lands. Or another thing we can do is we can start to play with the composition of this. We can actually give a little bit more depth, a little bit more interest to this by moving this not just along one dimension, because all really I'm doing is I'm just dropping it. And why? We can bring it in from the side, or some other dimension.

So let's go ahead and reopen a version of this. And let's go ahead and make this a little bit different. So I'm going to go forward, and let's go ahead just make our shot here. So this is where it lands. Again, I'm starting from the back. But for the first frame, I'm going to hop out here, and we're going to take a look at this from a little bit more of a-- so let's go ahead and get all Imperial battlecruiser on this. And we'll go ahead and just bring it in over the top.

So now it's coming in over the top. Maybe like this. And that gives a little bit more interest. Maybe here, instead of coming directly from the center, we're coming in from the side. And now when it comes in, again, we're getting a sense of depth. We're getting a sense of size. We're getting a little bit more interest in that scene.

I'm not going to have enough to do everything here, so we're going to move on, OK? Does that make sense? Is that pretty cool? OK, cool.

So now as we start to work with keyframing, and I mostly was just working with just position here, we are going to have to start working with what are called animation curves. I'm sure a lot of you have used animation curves. And when you set keys, they are interpreted using curves.

Now, there are a couple of rules of thumb for animation curves. One is it's a really good idea to use your curves as well as you can. I know a lot of animators who basically just keyframe everything. Every time they need something to be in one place, they put a keyframe there. And then the director comes back and he says-- you know what, this needs to be 10%, 20% faster. And now they've got to move 20 keys 10% back.

And then there are other animators who've had that happen a few times, and they've learned. And what they do is they try and make as few keys as possible and make their curves do the work. So when you have good animation curves, and you make the curves shape the motion, then your revisions become a lot easier. So if you only have three keys, then you can shorten it by 10% very easily-- all you have to do is just move a couple of keys, rather than 10 or 15.

So let's take a look at a real simple thing, such as a simple bouncing ball. So I've got a simple bouncing ball or-- let's go ahead and throw a ball into the air and use some animation curves. So I'm going to go ahead and just bring this back, say, negative 30. Set a key. Let's go forward to, say, 90. And let's go forward positive 30.

So what I'm trying to do here is get a sense of forward motion. And if we are throwing something, we want to make sure that it's moving linearly in a consistent direction here. So if I look at this, if I'd set this by default, you'll see that the animation curve has a slow in and a slow out. So if I were to play this back, it would go a little bit faster. And then-- oh, you can't see it because I block it. There we go. Go a little bit faster and then a little bit slower.

But we want to actually throw this ball through the air. So what I want to do is just make this go at a constant velocity. So I'm going to go ahead and make this a linear curve.

Does everybody understand the difference between linear curves and Bezier curves and all that stuff? OK.

So now this is just going a standard rate of speed. Now, if we're going to throw this in the air, it is going to be under the force of gravity. So when we throw it up, gravity keeps pulling on this until the upward velocity comes down, and then it will start to fall. So all we really have to do is just move it up. Here, let's go ahead and zoom out a little bit. And set a key there. And now it's going up, and then we have to zero it out. Set a key there. OK there. And so now it's moving up.

But that's actually a little slow. So let's go ahead-- because we only have a few keys we can actually bring that back a little bit. And now-- OK-- simple, simple throw.

But one of the things we're noticing here is if you look at this, it kind of slides into the start here. So if we look at this, you'll see that as it comes into this end, it kind of comes in at a curve. And that's because this is not linear. So we can take this, put it linear.

And now that we have this, it makes revising this that much easier, right? So all I have to do is just take this curve, and let's say we're throwing it into the wind, then all I have to do is just move that, adjust the curve, and now I've got a completely different character of motion. So instead of animating that. So this is all pretty simple.

Now, the other thing we need to do is, as we create motion the motion that we create needs to be interesting. So if we want to create animation that's engaging and interesting, we want to create interest via motion. So things such as straight lines are usually boring. You want to move things along arcs. We definitely want to stagger and overlap motions. And we can also use motion as another form of composition.

So I have a really simple example here of-- so here's a simple assembly of something coming in. But that's kind of boring. Let's go ahead and make this a little bit more interesting.

So if this comes in, we have this conveyor belt coming in, why don't we actually indicate what's going on with that? So instead of just moving these in, we're actually moving these in along a path, creating a curve through the scene, creating some visual interest.

Now this particular setup might not be exactly what we want but we can also go into another camera here. And, again, composition really plays a role here. So if we want to look at it from this view or a different view, we can do that.

So how we set it up, what we're telling the audience through our composition will be important. OK, another one here.

Here's another one where, again, we're staggering motion, creating a little bit more visual interest by staggering the parts as they come in. Very simple animation, but again it beats just bringing stuff in in blocks.

Another way to move things is via motion paths. We've been doing keyframing. We can also do things such as motion paths, which is spline or a curve placed in a scene.

We have something like this here. So if you wanted to make this airplane dive in a spiral, animating that on a keyframe is not going to work. So one of the things you can do is just use a motion path here. So we can just constrain this to a motion path, and it moves down, and then we can also do things such as bank it along the curve.

And then finally, we also have things such as non-linear editing. I'm not going to really get into that, but things such as the time editor in Maya, motion builder, all of that allows for global control of existing motion. So if you have motion capture, if you have something like motion capture of a fly by or something like that, you can use non-linear editing to do that workflow.

So let's talk a little bit about rigging. So as we work through animation, a lot of times you've got a lot of things to control. So when we typically need to animate something a lot, we will tend to rig it. Now good rig basically just makes connections between the objects. It turns a bunch of geometry into an actual system that we can animate.

And let me just show you a couple of different rigs here and it'll give you a sense what we have. So something like this. This would be a rig for a car. So you've got something that turns the wheels. You can rock the car. So on and so forth. If you actually move the car, it will actually roll the wheels for you.

So, again, all of this helps you to animate this car better. You don't want to have to sit there and animate all the wheels. You don't want to have to move all of the geometry. You want to just have simple control that allows you to manipulate the car.

Now, we have other types of rigs here. The classic rig is going to be the character rig. But all of these rigging tools can be used for anything. So in this particular character here obviously we know we've got rigs to control everything from the motion of the character to these are set driven keys that blink the eyes. We've got controls here for the mouth. All of these are in a Lynda.com course.

So, again, you have a lot of different controls over these characters. And the goal here is to make the controls animator-friendly. So if you were to, say, imagine this as something in a stop-motion that as a puppet sitting there on your desk. How would you manipulate it? And let's go ahead and put controls at the places where you would manipulate it. So if I wanted to rotate the arms, I want something at the shoulder and I want something at the elbow and so on.

Now rigging can also go beyond just simple. Rigging can also really automate the process. So here I've got a really complex gadget. It's a steam engine, driving gears, driving a conveyor belt. And we've got this rigged, basically, so all I have to do is rotate one thing and everything else moves accordingly. So all you have to do is rotate that one thing and the whole system moves.

And this is perfectly valid. I mean, if this is the way that this is going to move, then why do you need to do anything other than just animate the speed of the rotation? There's all sorts of ways to get these sorts of rigs together.

I've got about 10 minutes left. So let's go ahead through some simple rigging that we have. First one is-- I'm going to ask you if you know these things. So everybody is familiar with hierarchies, right? OK, good. Hierarchies are great ways to connect things in parent-child relationships. You know-- pivots control rotation, and that sort of thing.

We also have what are called constraints. Now, constraints basically tie multiple attributes together so that object motion can be controlled more easily. So let's go ahead just take a look at how constraints work real simply. So I've got something like this. This is the saucer. So if you want the leg to telescope, you can use what are called constraints. So I can, for example, have this object here look at the foot. So if I wanted to constrain what's called orientation, I can constrain that so that it's always looking at the foot.

Oh, wait, no, I'm sorry. So I could do-- I'm sorry, I did the wrong constraint. We can do what's called a look-at constraint or an aim constraint. And what this does is it actually aims at the object. Let's go ahead and reload this and do it again.

So I can take this and add what's called an aim constraint. So now it's aiming at that leg no matter where it goes. I can do something that, say, constrains this object between these objects, so we can do what's called a point constraint. So now this helper object here is constrained between this object and this object. So now I can do that. And then we can use hierarchies.

So, for example, I can take this cylinder here, put it beneath there. So now this is moving with that. And as you can see constraints can really start to--

AUDIENCE: [INAUDIBLE]

GEORGE MAESTRI: What's that?

And then I'm going to go ahead and just jump ahead here. So this rig is basically just constraints. So all of that telescoping has constraints. Got seven minutes left here.

OK, another one are joints and IK. So joints are typically done for character animation. They can simulate the bones of a character. But you can also use them for all sorts of other, non-character animation related tasks.

Now, we have two types of ways to manipulate joints. One is called forward kinematics, where you rotate the joints. The other one is called inverse kinematics, where it's translation-based. Let me see if I've got something here.

So, basically, in Maya we have what are called joints. Are you familiar with-- or you'd have them in 3ds Max-- it'd be under rigging. And so we can do what's called a IK handle here, which allows you to use position to control it.

And then we also have other ways of doing that. We have deformations, which allow you to deform an object based upon a joint. And then we also have what are called scripts and expressions. And so that is where we get into software to control rigs.

Now, expressions are usually simpler-- they're just basic math. They're time-based, that sort of thing. So, for example, if we have something like this. So if you want one gear to move another, you would use an expression that basically just rotates one in proportion to the number of gears.

So that's kind of basically-- we're running out of time here so I'm going to stop here and open it up to any questions. Questions? No, OK.

So that's basically it. And just as a reminder, I work for LinkedIn. And, if you want, in your Autodesk University app we do have under special offers we have a 30 day free trial for everybody attending the conference to LinkedIn Learning, where we have tons of courses on Autodesk products, as well as everything else from Adobe, Microsoft, everything. Lots of great learning. I know that's what this is all about-- we have tons of that. And then Lynda.com is also a part of us and we also have tons of courses on this. So thank you very much.

[APPLAUSE]