

Design Course

Bouncing Ball Animation

Level: Introductory

by

Prof. Sumant Rao and Nitin Anand

IDC, IIT Bombay

Source:

<http://www.dsource.in/course/bouncing-ball-animation>



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<http://www.dsource.in/course/bouncing-ball-animation/introduction>

Introduction

What makes one go 'WOW!' when they see good animation? It is some basic principles used in an interesting manner. To learn these, you do not need to learn complex character animation. You can do that from very simple ones. Once you have mastered them, you can apply what you have learnt to create the complex stuff.

One such example is the bouncing ball exercise. This is a very standard exercise done even in 2D animation.

Check the below link for bouncing ball example:

(http://www.dsource.in/course/principles_of_animation/squash-n-stretch/index.html)

This is also an equally good exercise to do in 3D. In this module you will go through all the basic stages that you will need to do both simple as well as complex animation. It will take you step by step from the beginning to finally creating an animation sequence of the bouncing ball. At the end, you will be ready to start with the more complex stuff.



You will be surprised with how even something as simple as animating a ball bouncing can teach you so much about animation and hopefully you will be able to use these stages in all the animation that you do.

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a. Research and Referencing:

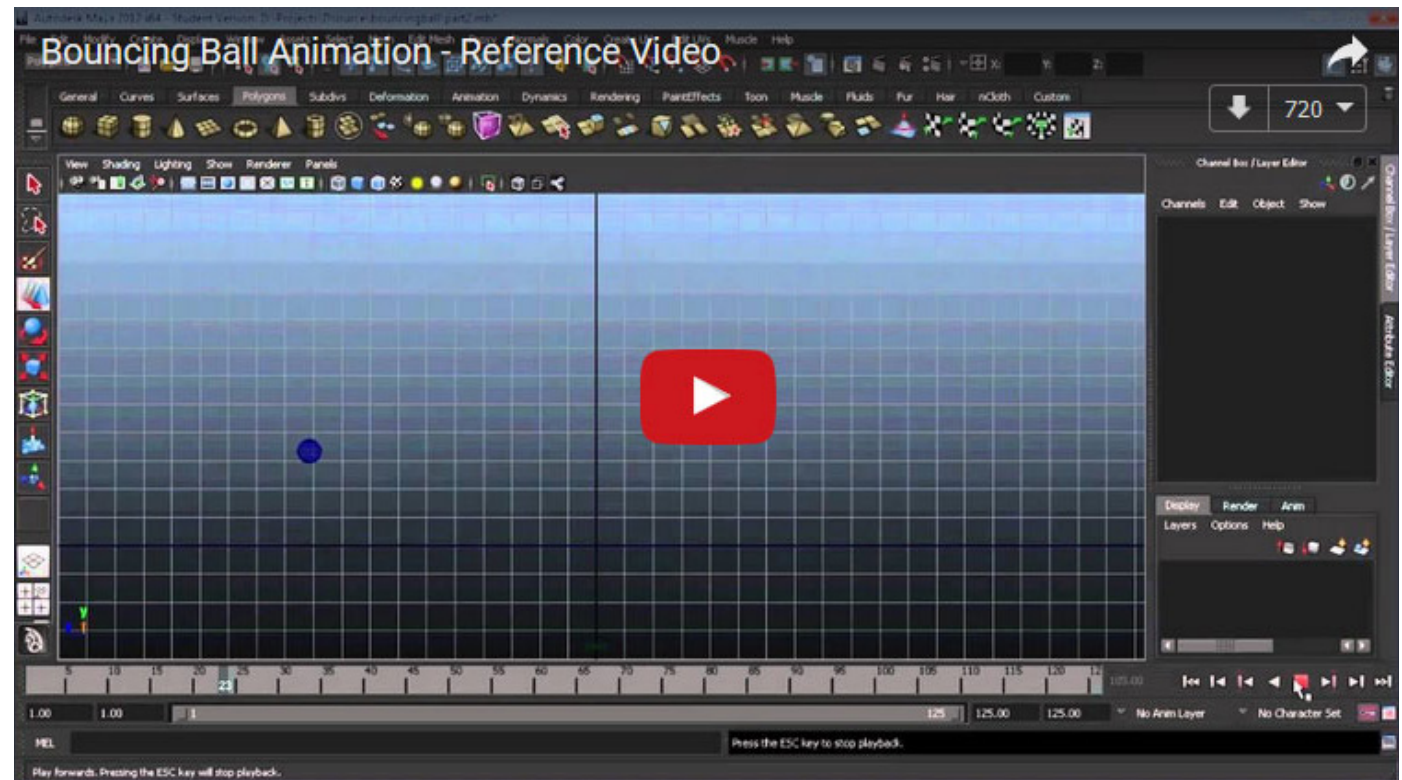
For becoming a good animator, the art of observation is very important. You need to know very well, whatever you need to animate. So you need to try and get good references for it, study them well and learn to feel the animation (the WOW!) as well as understand the mechanics of what makes it work so that you can use the software to create it (the HOW?).

b. Observation:

For this module, we have shot a simple reference of a bouncing ball. Download and study it well before attempting to animate.

Refer the Video:

Bouncing-Ball - Reference Video



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<http://www.dsource.in/course/bouncing-ball-animation/creating-scene>

Creating the Scene

Before you can animate, everything has to be created. This would include the sets, props, the objects or characters you need to animate, EVERYTHING! For more complex scenes, you will need to do a lot of planning.

If you were making a film, you would have perhaps, already made a storyboard and an animatic, which tells you roughly how your film communicates, how many shots are needed, how each shot would look - i.e. the composition, camera angles and what is the action in each shot and what is its duration.

Based on this you can create all the assets required in a particular shot.

For more details on **Storyboarding and Animatic** you can check the below module:

(<http://www.dsource.in/course/storyboard-and-animatic-animation>)

The purpose of this exercise though is not making a film and what we need is very obvious, all we need is the ground for the ball to bounce on and the ball itself.

a. Creating the Assets - Primitives:

The objects that we need to create are very simple geometric shapes, called as Primitives in 3D. All we need is to create a Plane for the ground and a Sphere for the ball. These Primitives can be created easily by the software, if you specify the basic parameters of the object.

For example: The **length** and **breadth** of the plane and the **radius** of the ball. Besides this, you may also have to tell the software how many subdivisions you need to create.

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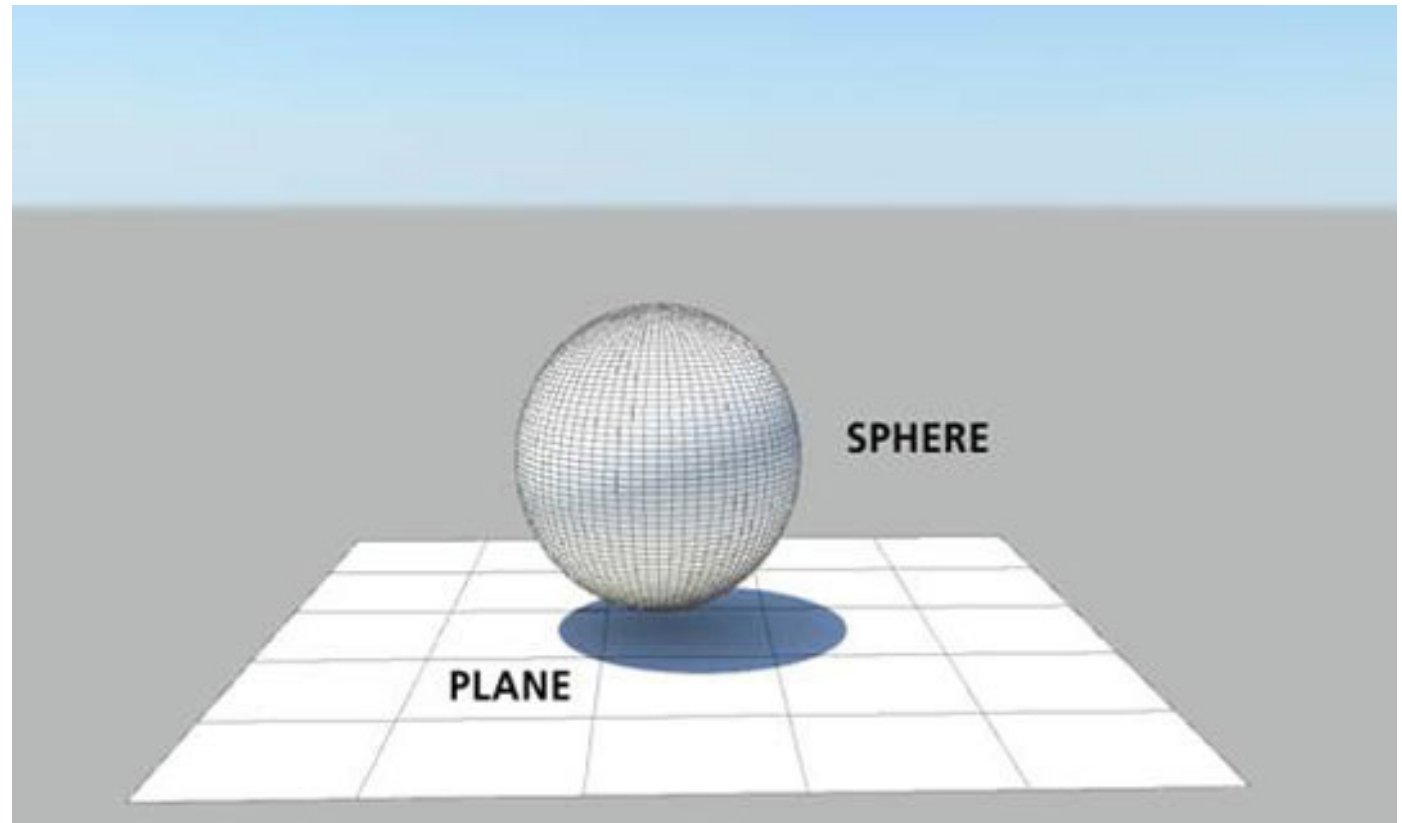
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Exercise:

Think of other simple geometric shapes like these that perhaps can be Primitive 3D objects. Make a list of them. Then check in your software whether it allows you to create them. Also, you can check for other objects that you may have not thought of.

In the process of creation and later animation, you may need to select, position, rotate and scale the ball. Familiarise yourselves with where these tools are. Most softwares will have them easily accessible on the main interface and also have shortcuts that you can use to select them.

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For more details on **Interface** you can check the below module:
(link)

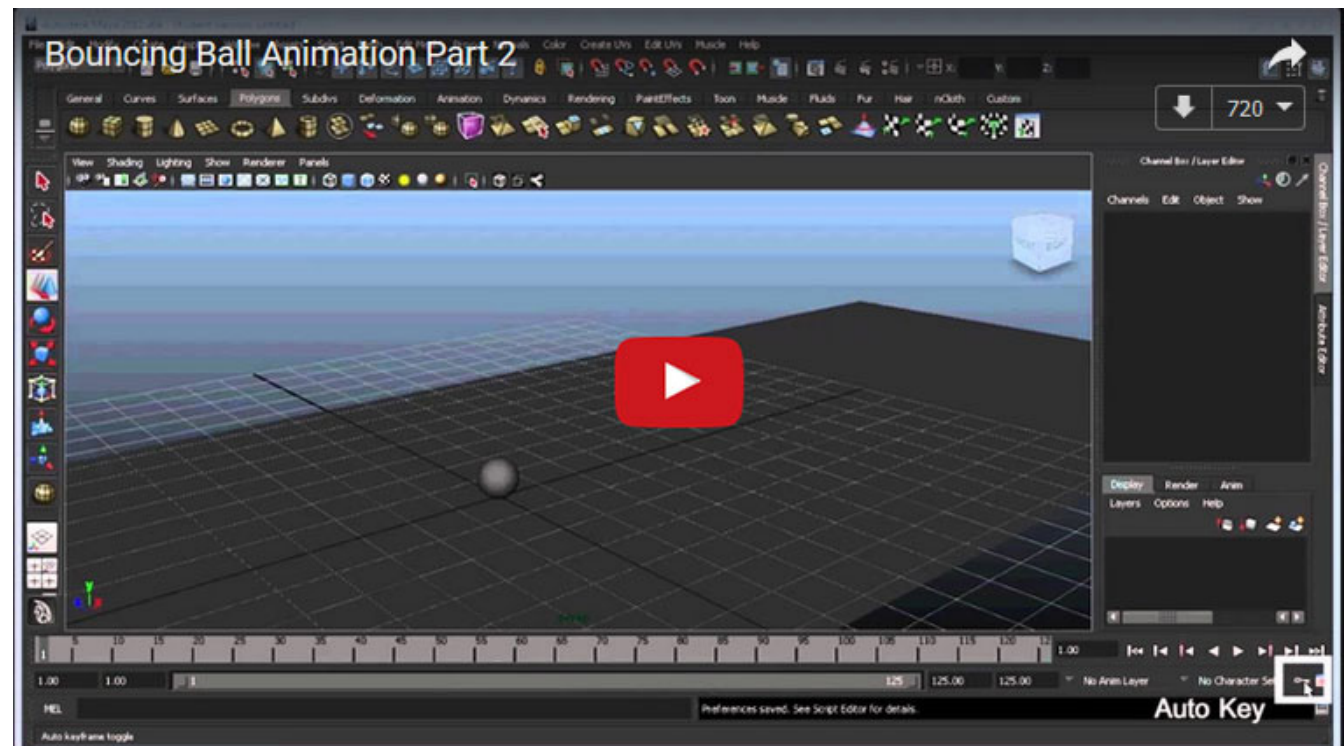
When you select any tool, the software will also display a manipulator around the selected object that allows you to change its value. Experiment with this. You will need to do this all the time.

b. Preparing the Scene:

After planning for the scene to be animated you need to 'Prepare the scene' for animation using software. The below video will show you the process of doing same using Maya. But the process is just as simple in any software that you choose to use.

Remember, you need a plane long enough for the ball to bounce and roll until it comes to a stop. And the size of the ball with respect to the floor should also be in proportion.

Refer the Video:
Bouncing-Ball Part-2



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<http://www.dsource.in/course/bouncing-ball-animation/creating-scene>

c. Setting the Frame Rate:

Before you begin animating, you will need to be sure of one thing - the speed of your final film i.e. The frame rate of your animation or the frames per second (fps) at which your video plays.

This will change depending on where your film will be seen, whether in a movie theater, on your TV, or on the Internet and even in which country. Here is a table of the most common speeds of film.

FPS	Format
24	Movies (in a theater)
25	PAL - the TV system in India, UK and many other countries
30 (29.97)	NTSC - the TV system in USA and other countries

In India, most often, you will need to use 24 or 25fps. Your software will allow you to set this frame rate. Make sure with each new project you are working on, it has been set correctly.

Imagine, what would happen if we created animation at 30 fps and then saw it on TV. Since TV would play it at 25 fps, the video will play slower stretching the animation by 5 frames every second. The sound will perhaps still play at the same speed and go out of sync with the video and your overall film will be lengthened in time by as much as 20%!

Ofcourse you would not want that to happen with your video. Would you?
So make sure that you get into the habit of using the correct fps.

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Source:

<http://www.dsource.in/course/bouncing-ball-animation/planning-animation>

Planning for Animation

Before you get down to animating, it is important to take some time planning your animation. This is a good time to look at your research, reference material and observations made from them closely. In our case, take a look at the reference video of the basketball. Notice the 'Timing' of the bounces of the ball. Duration between each successive bounce is lesser than the previous one.

Simple as this exercise may seem, Timing is one of the important principles of animation.

For more details on **Timing** you can check the below module on Principles of Animation:

(<http://www.dsource.in/course/principles-animation/timing>)

a. Identifying Keys and Timing:

If you observe the reference carefully, the timing between the first two bounces is around a second. In PAL, this is 25 frames. Accordingly, you can plan the number of frames between each successive bounce. Based on this, you will be able to calculate the frame of animation at which each bounce occurs. Identifying these frames where the ball bounces are the 'key' to good animation. Hence they are called as Keyframes. The other frames are a simple interpolation of the animated object or character from one keyframe to another.

b. Planning - Spreadsheets and Exposure sheets:

You can use a simple table (or a spreadsheet) to plan your animation. Here, in the below table you can see how we have planned the timing of the bounces for our animation.

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Bounce	Frames	Frame No
1	0	1
2	24	25
3	20	45
4	16	61
5	12	73
6	9	82
7	6	88
8	4	92

For more complicated animation, you can use exposure sheets to plan out your animation in more detail. If you were doing 2D animation, this becomes even more important as you need to draw every keyframe and not just move objects around as required.

For more details on **Storyboard Template** you can check the below module:

(<http://www.dsource.in/course/storyboard-and-animatic-animation/storyboard-animation/basic-storyboard-template>)

Understanding exposure sheets will help you a lot. Especially if, you are trying to combine 3D with some 2D animation.

Now you are truly ready to animate!

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Source:

<http://www.dsource.in/course/bouncing-ball-animation/keyframing>

Keyframing

Let us start by adding the keyframes for each bounce.

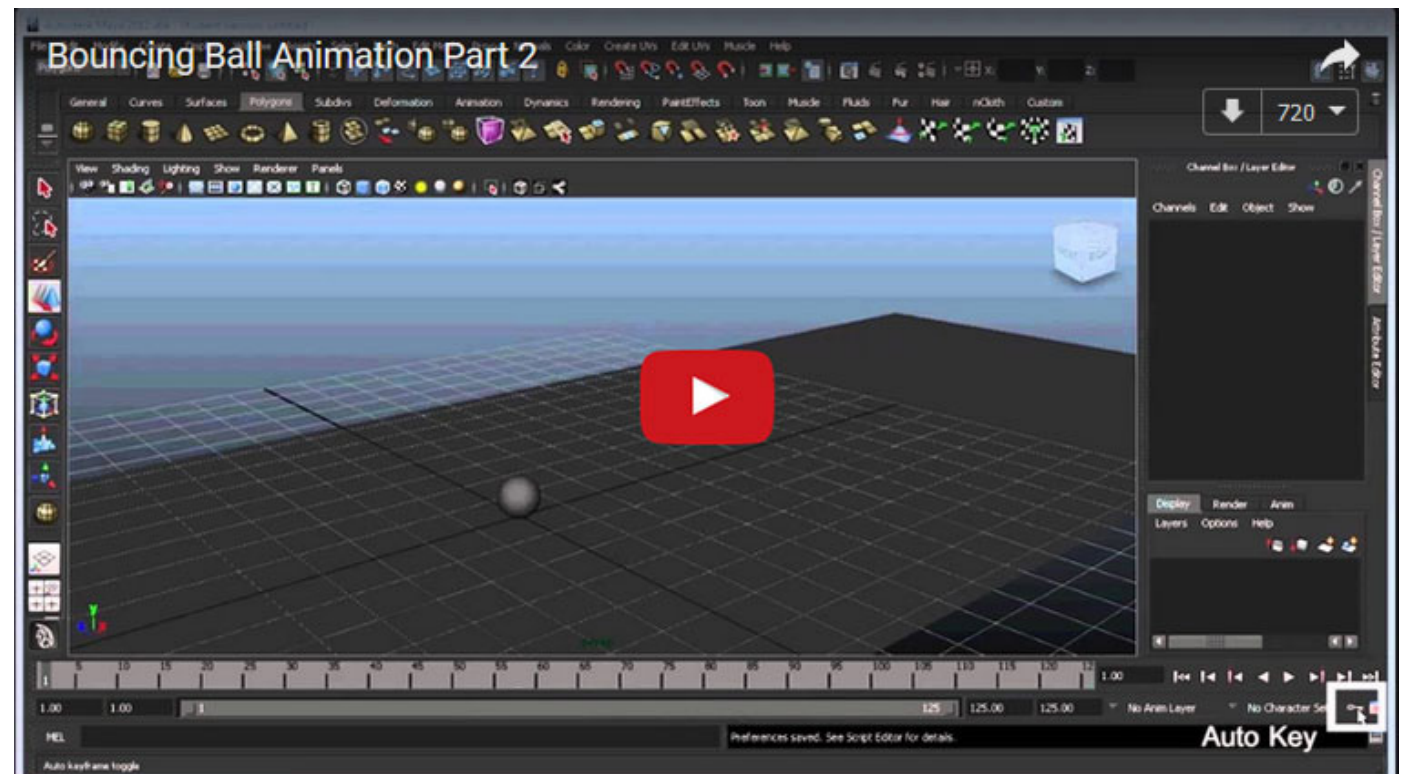
i.e. Position of the ball on the frames that the ball bounces each time as we have planned.

You will have to go to the specific frame on the timeline, select and move the ball to the position you want and set a 'key' for it. If you are using software other than Maya, before starting make sure that you set keyframes on the timeline for an object.

Most software's will allow you to add keys automatically by switching on an autokey button. Keep the autokey button switched 'ON'. This will automatically set a key at the current frame for any change that you make to your selected object.

Refer the Video for details:

Bouncing-Ball Part-2



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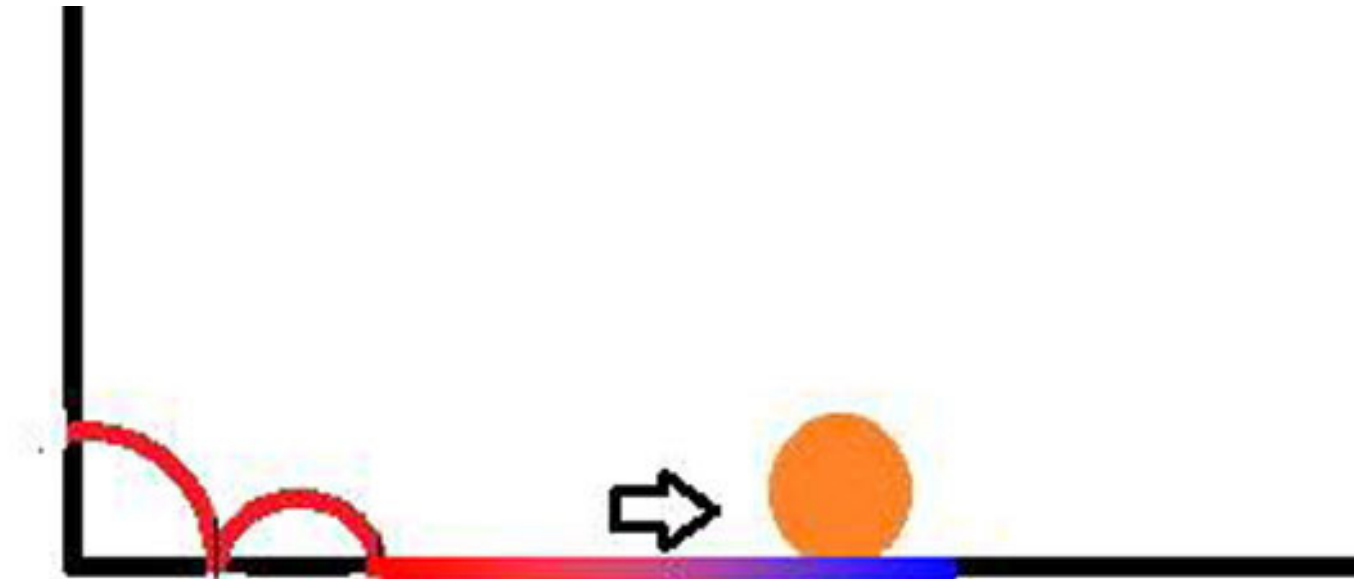
Source:

<http://www.dsource.in/course/bouncing-ball-animation/keyframing>

Now, let's go to the orthographic side window and move the ball to the first position.

Simply press  +  on the keyboard to add the first position keyframe.

On the timeline move the cursor to 25th frame and move the ball to the next bounce position. Repeat this to add all the bounce keyframes. Note that the distance between each bounce will be lesser and lesser. Now we can add the keyframes for the middle positions between the bounces. Keep in mind that, each time the ball will bounce less as you do this until it stops bouncing. After this, the ball will roll along the floor until it comes to a stop. Hence, the last keyframe will be a few frames ahead after the ball stops bouncing.



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Source:

<http://www.dsource.in/course/bouncing-ball-animation/previewing-animation>

Previewing the Animation

Imagine you were doing cutout animation, clay animation or even hand-drawn animation on paper. To see whether the animation you were doing is right, you will have to somehow create a video; either by taking it into a computer or making a video of it to be sure that it works.

The best part of doing animation on the computer is the immediate feedback that it is able to give you. You can preview what you have done at any time during your animation so as to be sure you are doing it right and modify accordingly.

There are two ways to check this:

- The first is pressing the playback button on the timeline.
- The second is by quickly creating a small preview video (called Playblast in Maya)

But then, you might think:

- Why not just use the playback button on the timeline?
- Why do you sometimes need to make a video preview of your animation?

This is because; sometimes the scene you are animating might be very heavily dependent on the capacity of your computer to handle it. This may be because your scene consists of multiple characters, objects, hair or fur simulation or other modifiers which take time to compute. So the playback may skip frames if you have enabled the real time mode in the animation settings or play very slowly if you have not.

On the other hand, if your scene is not very heavy and real-time mode is not on, the playback may actually play much faster and you may end up setting keyframes with wrong timing based on how the playback looks. So for judging the correct timing of your animation, it is really important to switch the real-time mode 'ON' in the animation settings.

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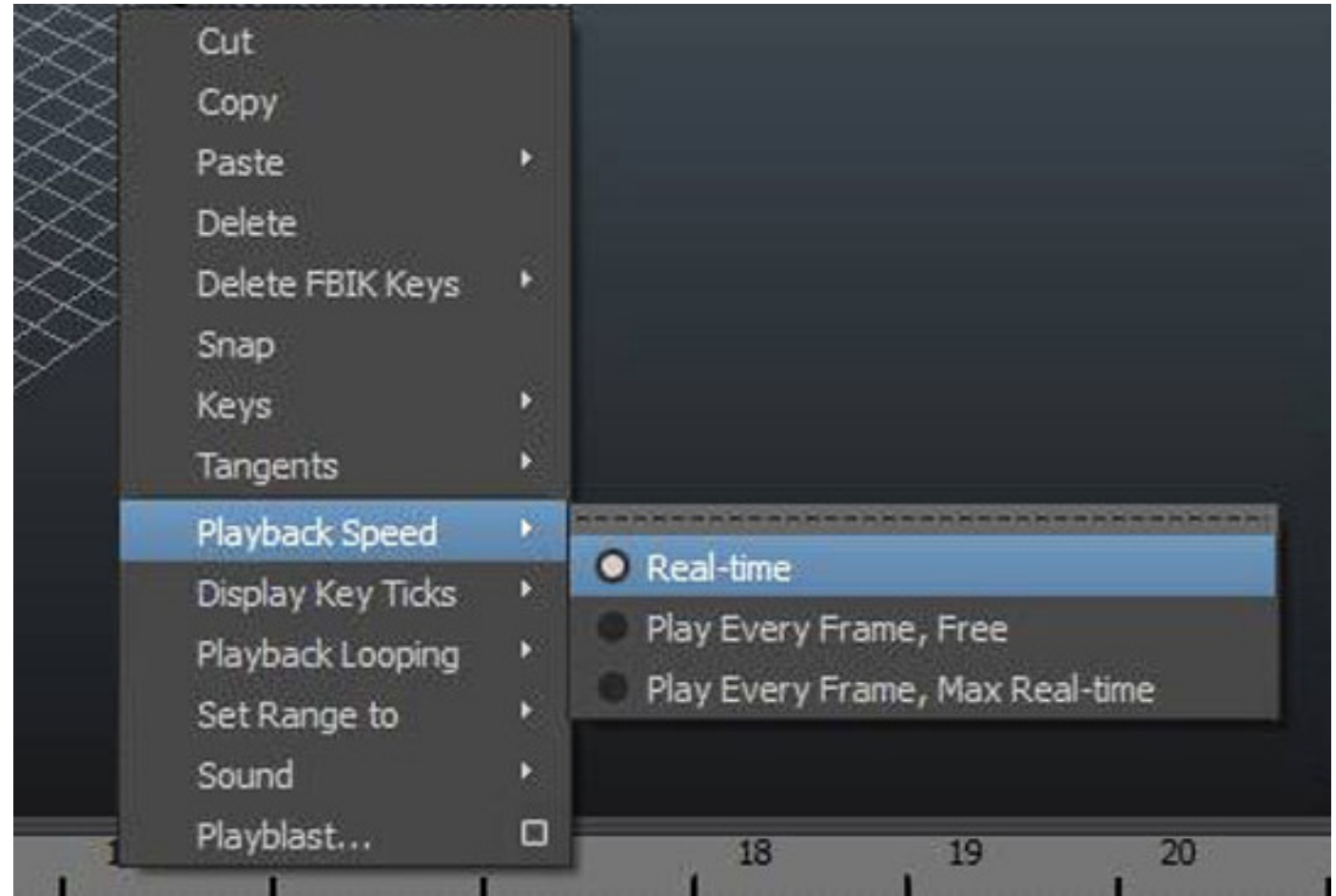
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For animation settings you can use below options:

(Animation Preferences -> Settings -> Time Slider->Playback speed: Real-time[25fps])

or

(Right click on the timeline window and switch on the real-time toggle in the Playback Speed setting in Maya fig 4.)



Check the playback of the animation we have done till now in the video. Does it look right?

You will need to develop a keen sense of observation so as to improve your animation by studying the playback. Try and figure out what the problem with the playback is and in the next part you will find out if you were right and how to go about correcting that.

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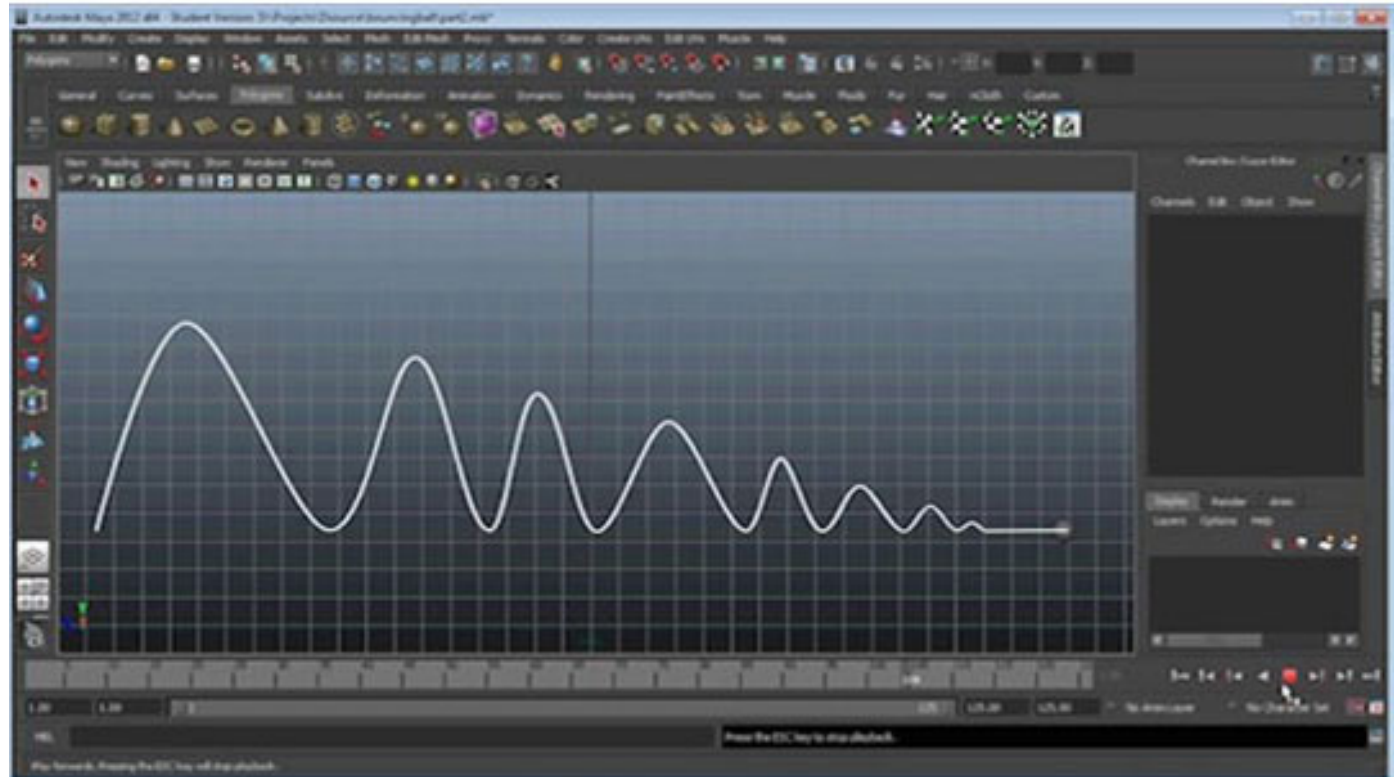
Source:

<http://www.dsource.in/course/bouncing-ball-animation/interpolation-between-keyframes>

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Interpolation between Keyframes

When you look closely at the playback, there seems to be something wrong with the part where the ball bounces on the ground. Instead of actually bouncing it seems to be going more in a wavy path.



The reason is, the way most of the 3D software create the intermediate frames of animation i.e. interpolate between two consecutive keyframes. The software assumes that you want to start slowly from a state of rest (from one keyframe) and come slowly to rest at the next.

In the real world, this is very common. Remember Newton's laws of Motion? Anything that is in a state of rest or in motion remains in that state unless there is external force acting on it. This is also called as Inertia. Hence, it is much rare to find some objects suddenly changing the direction and much more common for this to happen over some time and smoothly. In fact, this is an important principle of animation called Slow in Slow out. In 3D this is called Ease in Ease out.

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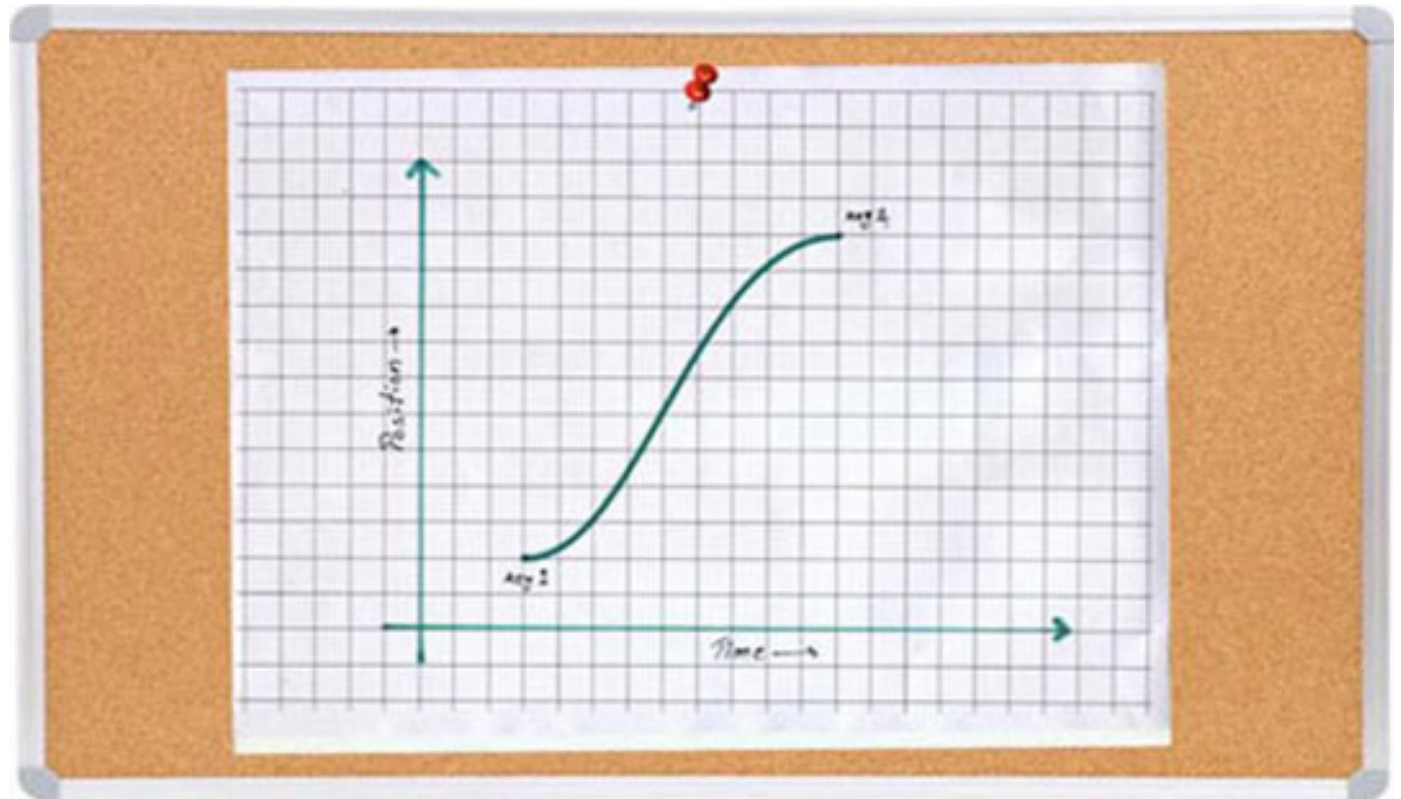
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For more details on **Ease in Ease out** you can check the below module on Principles of Animation: (<http://dsource.in/course/principles-animation/slow-slow-out>)

For example:

- When a car which starts from speed zero and accelerates to a speed, then decelerates to stop.



- But this is not the case with the bouncing ball. At the point of the bounce, when it hits the floor, the ball changes direction and speed from downwards to upwards almost immediately.

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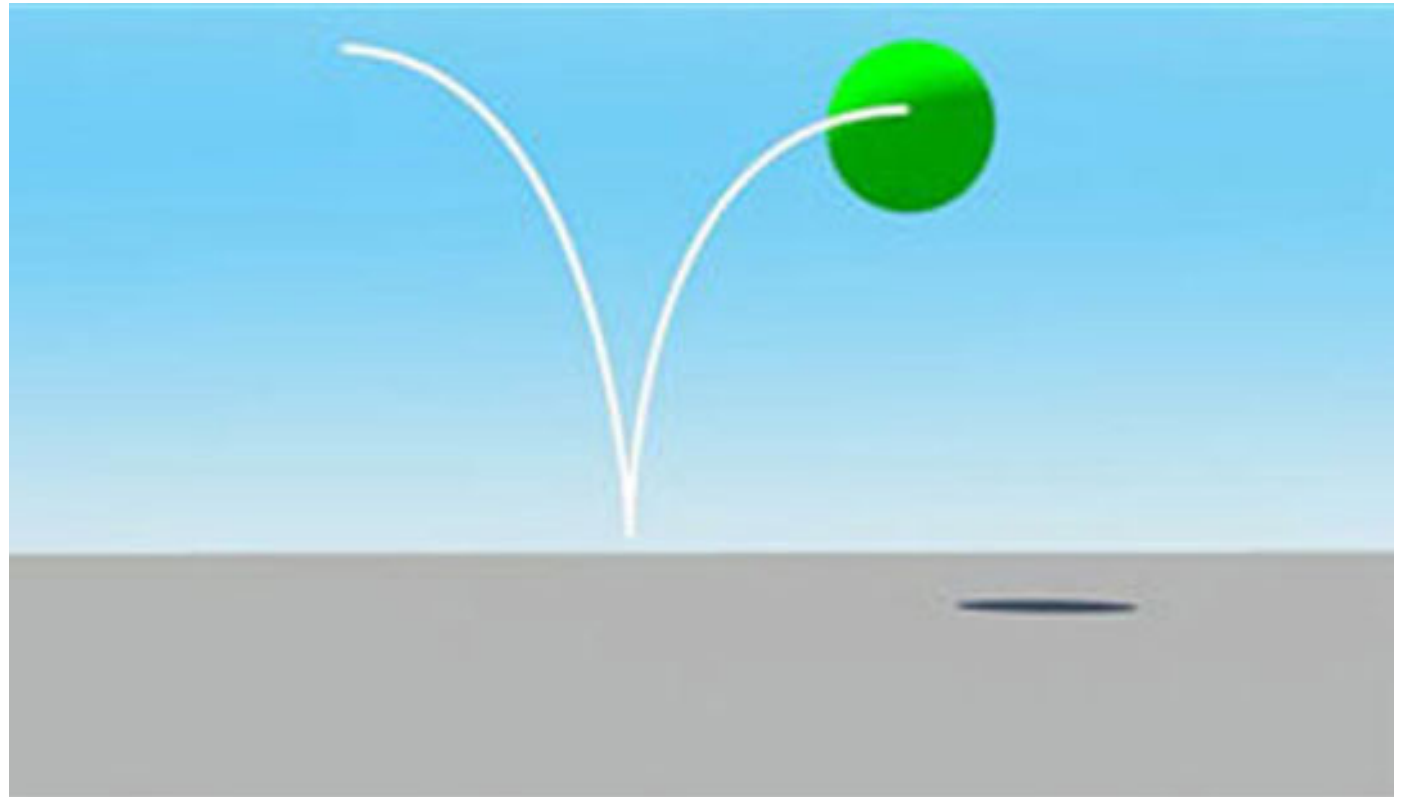
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This would also be the case if a ball was hit by a bat or for that matter collision between any two objects. On the other hand, if there was a car going down a curving road, it may be moving at the same speed down the road, but constantly changing direction.

Hence for any specific animation that you are working on, you will have to figure out, for each keyframe, exactly how the value changes while coming to that keyframe and going out of it.

Any 3D software will allow you to change the way it interpolates from one keyframe to the next by manipulating the graph of that parameter, in this case, translation. This can be done in Graph Editor.

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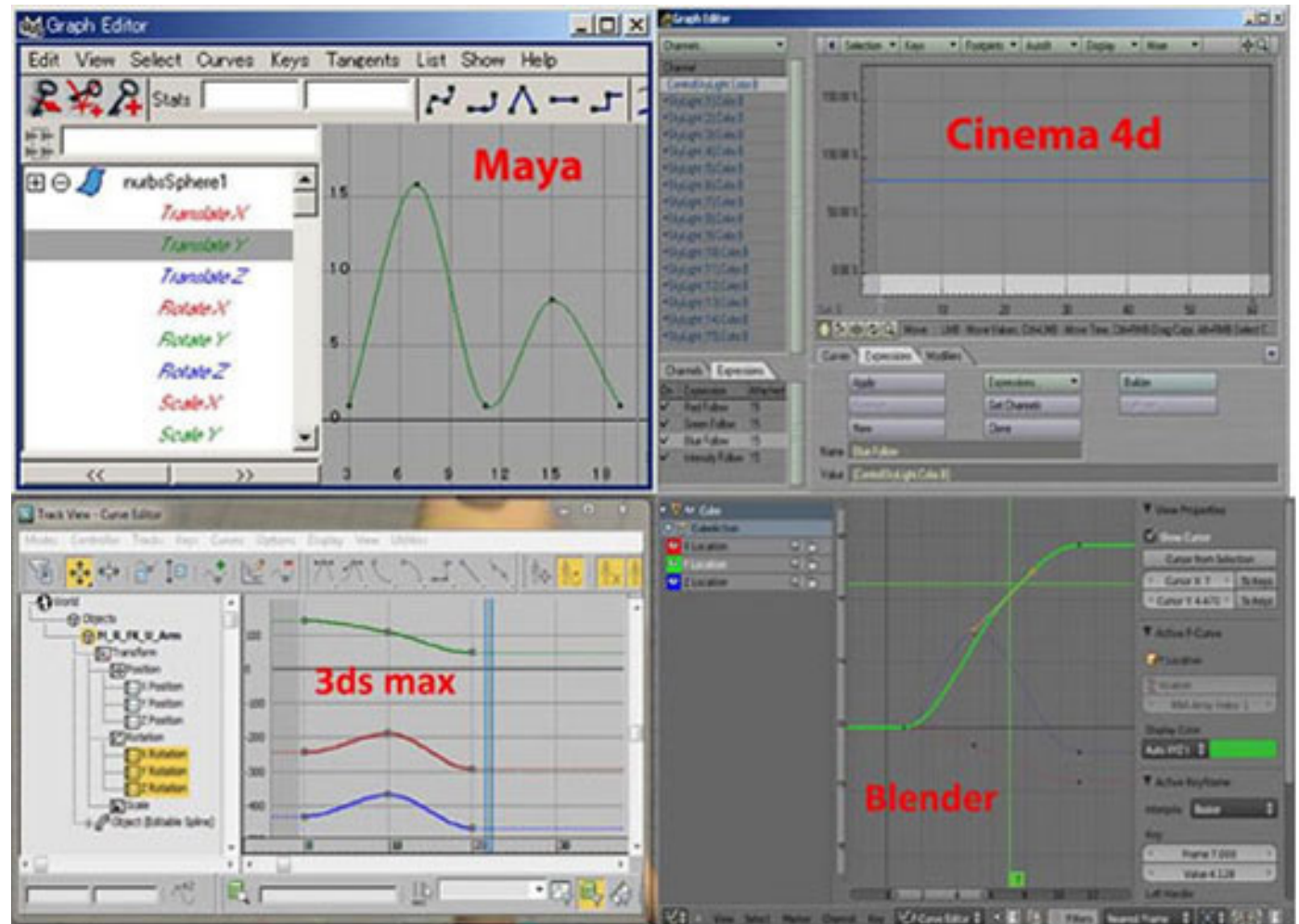
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So, What are the types of transitions that you might want from one keyframe to the next?
Let us look at a few examples.

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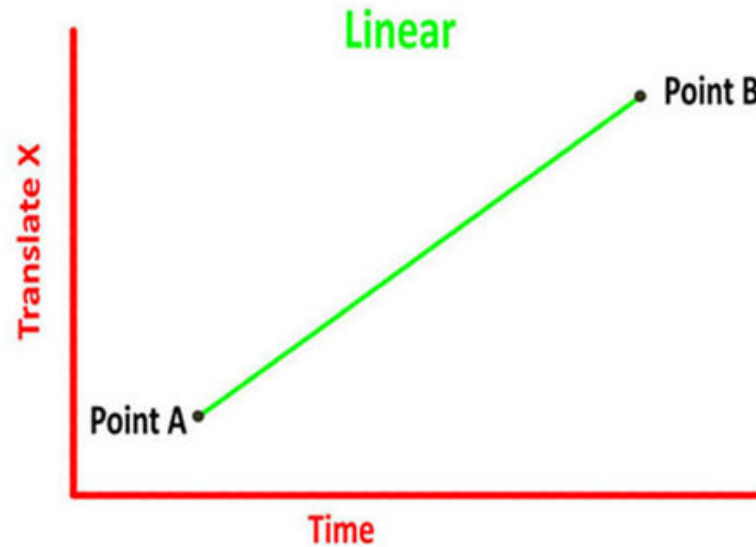
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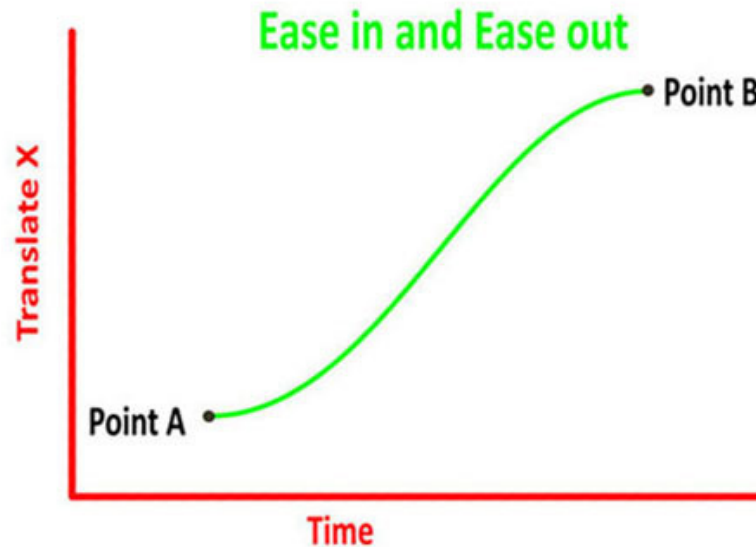
Example 1:

A car moving at constant speed in a straight line from point A to point B.



Example 2:

A stationary car starting from point A, accelerating and then slowing down till it comes to a stop at point B.



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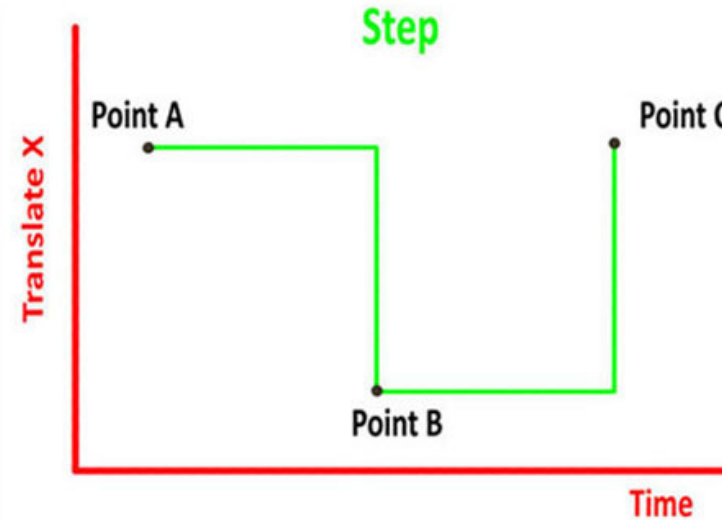
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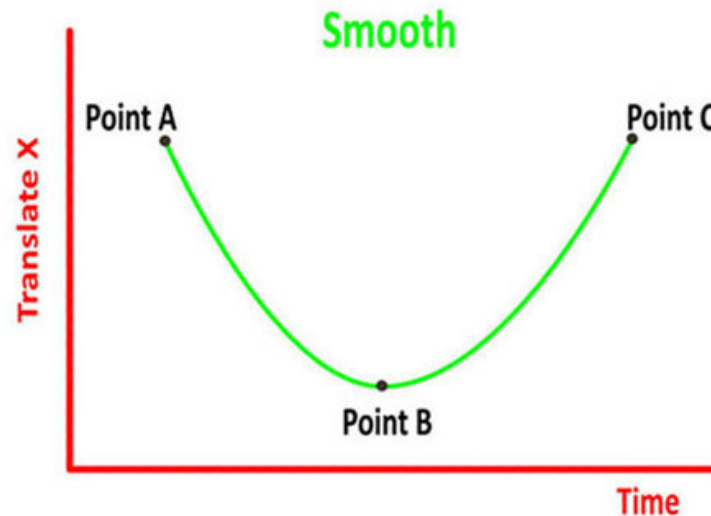
Example 3:

An animation where you would like to create a very staccato motion effect for an object, where it freezes for a few frames in one position before suddenly switching to the next one.



Example 4:

When you have more than 2 keyframes and you want the value to change as smoothly as possible between them (without needing to ease-in and ease-out).



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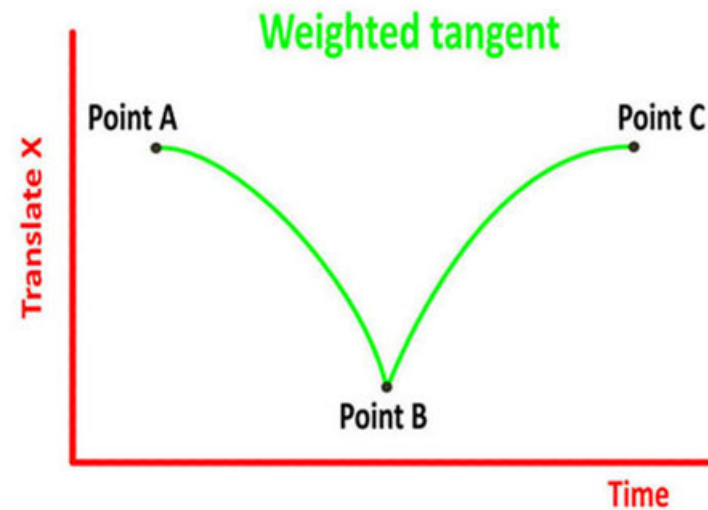
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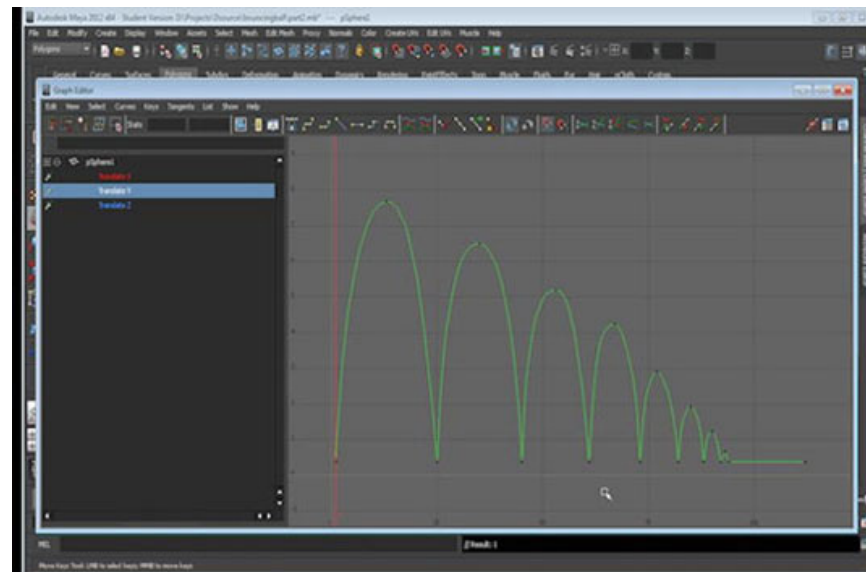
<http://www.dsource.in/course/bouncing-ball-animation/interpolation-between-keyframes>

Example 5:

Finally, more control - That you may want to create the exact way the value changes between keyframes.



Considering the above examples, you can change the graph of the ball from the wavy to something more like this.



But this is only in the upward (y - axis) direction.

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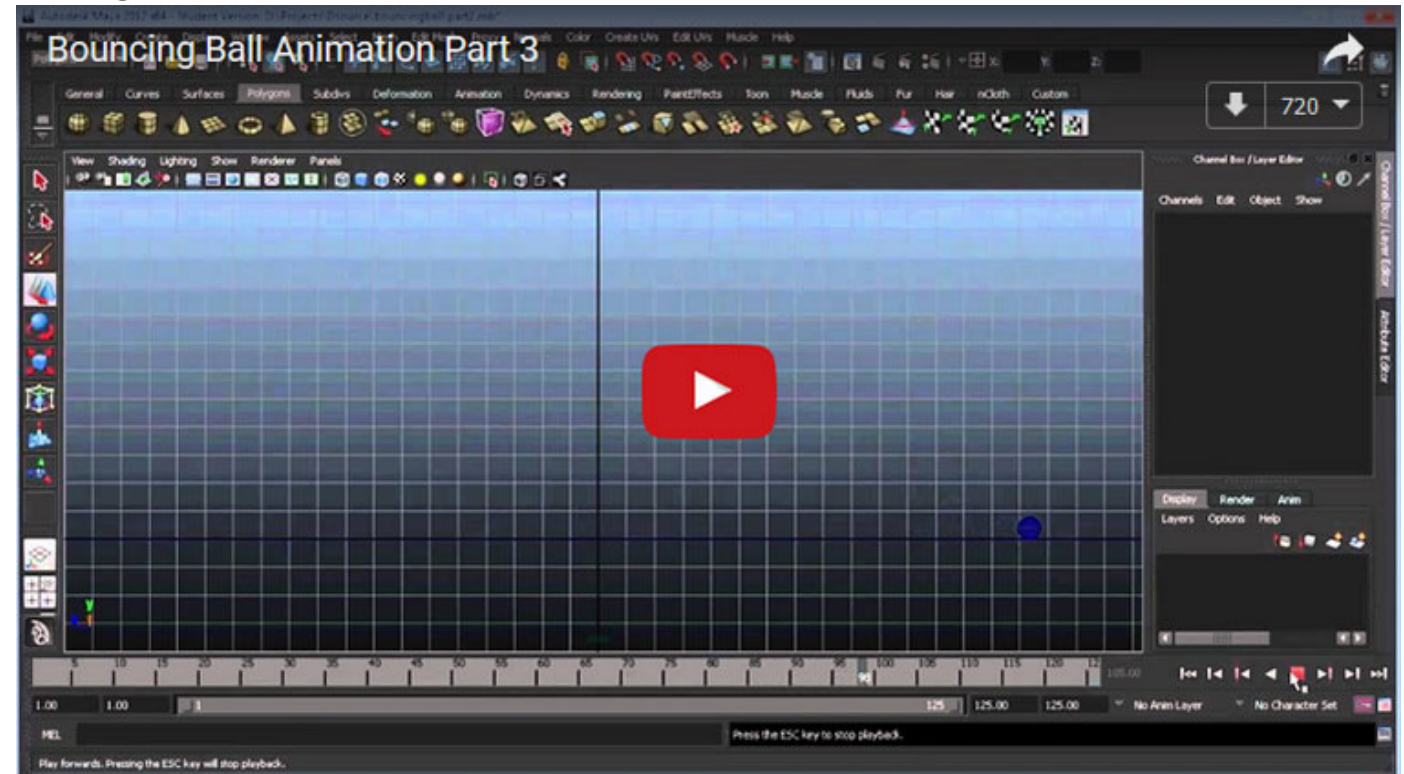
Source:

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A simple thumb rule when you are animating is to keep your keyframes limited to what is essential and delete those that are not needed. This often will help you control your animation.

Refer the Video for details:

Bouncing-Ball Part-3



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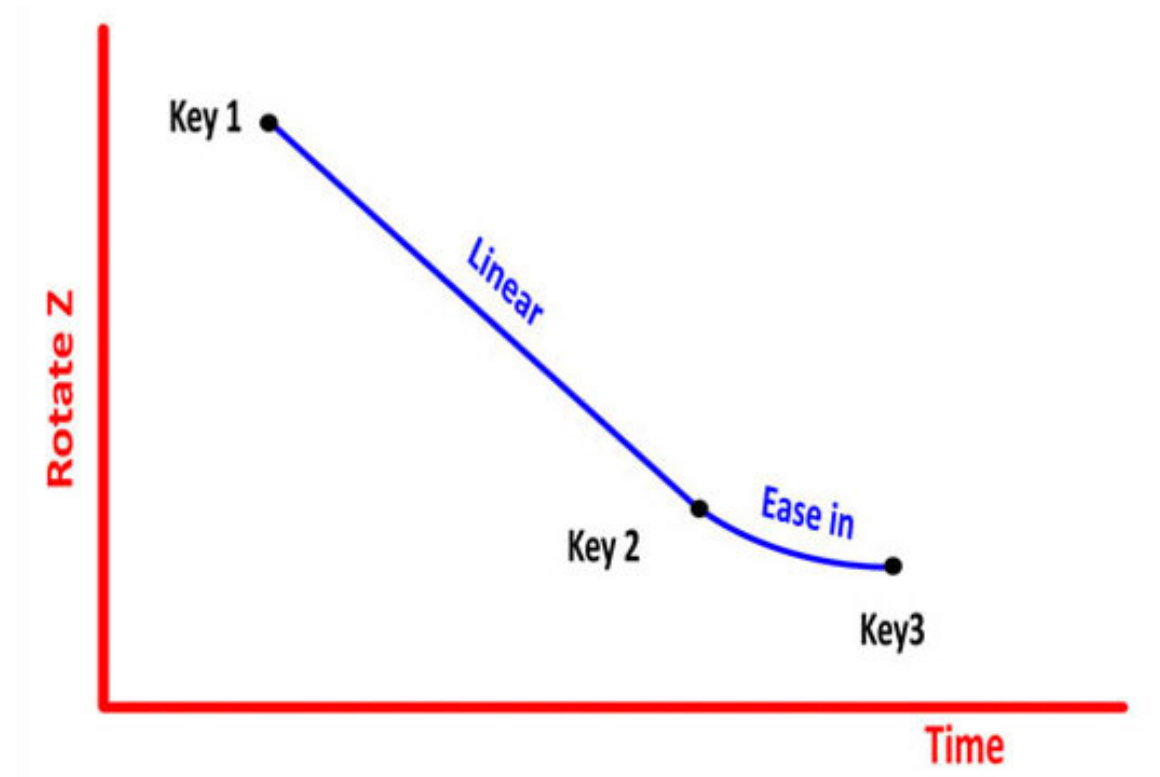
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As the video explains, in the (z axis), you can do this by deleting all keyframes between the first and the second last keyframe from where the ball starts rolling along the ground and make this part of the graph linear. This is because in this direction, there is no opposing force, the ball barely slows down until it starts rolling after which it naturally comes to a stop slowly (ease in).



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Source:

<http://www.dsource.in/course/bouncing-ball-animation/adding-rotation>



Adding Rotation

Till now we were animating the position of the ball. But, along with the position, the rotation of the ball is also an important part in bouncing ball animation. Since the ball is a perfect sphere and was in shaded mode we were not able to understand its rotation. But when we toggle the display to wireframe mode and take a closer look at the ball it is obvious that it needs to rotate.

We can do this with just 3 keyframes:

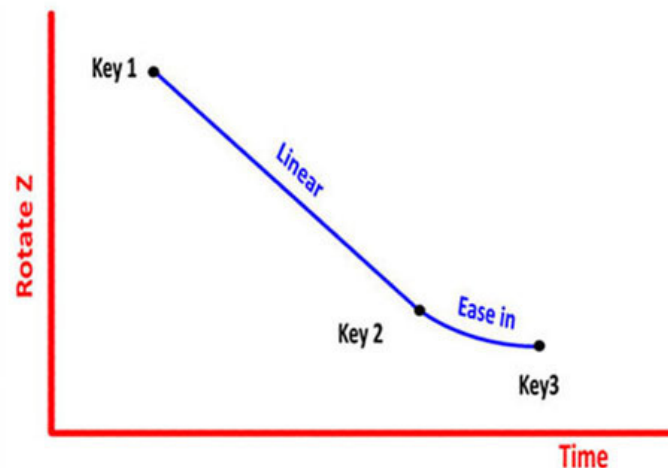
- the first frame,
- the second last frame, when the bouncing stops and
- the last one where the ball comes to a stop.

Set a keyframe for rotation on the first frame.

(For Maya software users use the short-key  + ).

Then go to the keyframe where the ball stops bouncing and starts rolling along the ground. Rotate the ball using the manipulator to the amount you want. The autokey button is on, so it will now automatically set a rotation key at this frame. Then go to the last keyframe, where the ball comes to a stop and rotate the ball some more.

In the forward motion of the ball, there is no force slowing down the ball from rotating until it starts rolling along the ground. Similarly, the graph should look similar to the translate-z graph, i.e. linear between the first 2 keyframes and then ease-in to the last keyframe.



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Check the playback again.

And, your “Bouncing ball animation” is complete.

Hope you understood how to animate the bouncing ball. Experiment with it. Try out animating balls of different sizes, mass and other properties.

Source:

<http://www.dsource.in/course/bouncing-ball-animation/adding-rotation>

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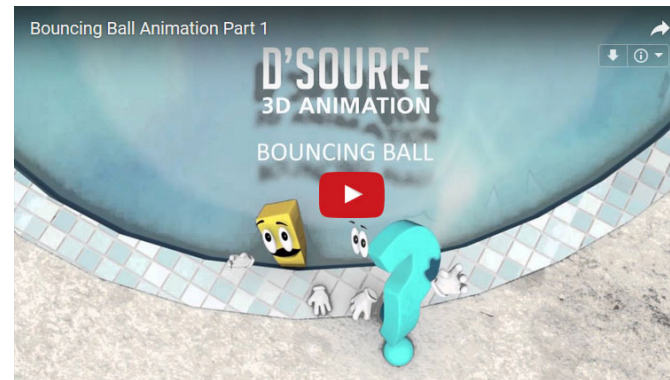
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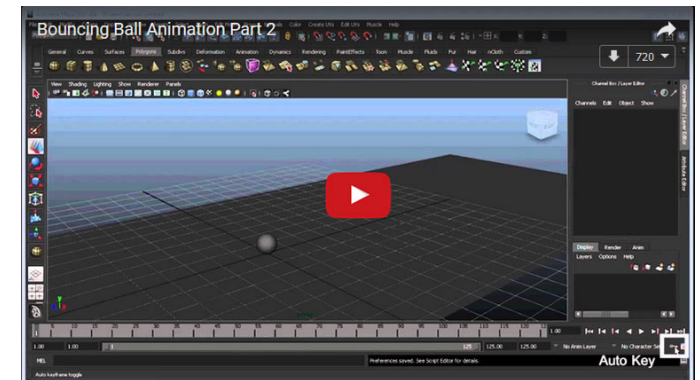
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<http://www.dsource.in/course/bouncing-ball-animation/video>

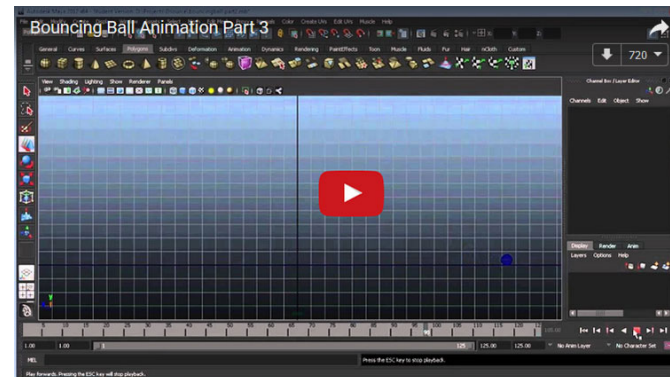
Video



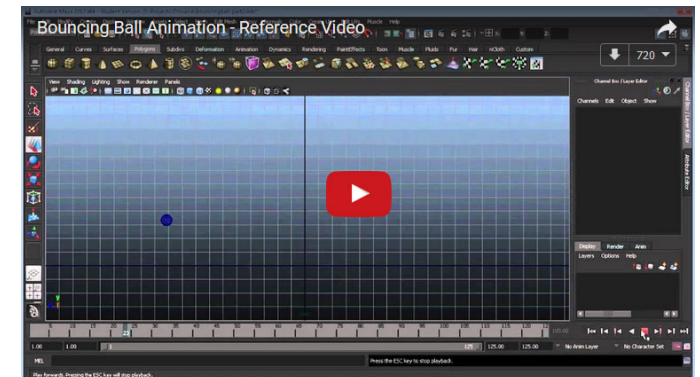
Bouncing Ball Part 1



Bouncing Ball Part 2



Bouncing Ball Part 3



Bouncing Ball - Reference Video

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Source:

<http://www.dsource.in/course/bouncing-ball-animation/contact-details>

Contact Details

This documentation for the course was done by Nitin Anand at **IDC, IIT Bombay**.

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