ANIMATION: FIRST LESSON (link to lesson)

Summary/Overview:
In this lesson, you'll use animation tools to bring a ball to life. Along the way, you'll learn some basic principles of animation.

Lesson Structure: This lesson contains 6 videos and 6 exercises which alternate back and forth. One way to run this is to watch and discuss all videos as a group (using a screen at the front of the room) while letting students return to their computers to do the exercises when required.

Total Time Recommended:
Approximately 90-120 minutes to complete the videos and exercises.

Age: Grade 5 - infinity and beyond!

Objectives:
In this lesson, students will:
- Learn how Pixar uses drawing and computers to create animation
- Become familiar with splines and their expressive potential
- Learn about both straight ahead and keyframe animation techniques

Materials Needed:
- Indoor classroom, lab, or open space with seating and access to the Internet. Space should have enough seating, ideally facing a teacher/facilitator's projection screen.
- Teacher/facilitator should have a computer connected to a large monitor or projector and speakers.
- This lesson assumes that each student or pair of students will require a device to access the lessons online.

VIDEO 0: Math Meets Artistry (length: 3 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video "Math Meets Artistry" When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Animation** - Making changes to a series of images and playing those images back in sequence.
- **Key poses** - Important poses a character hits (usually at the start/end of an action) which are filled in with a series of in-between frames.
- **In-betweens** - These are frames that connect the motion from one key pose to another.
- **Posing** - Setting the positioning a character
- **Spline** - A curve that defines how the frames are drawn in-between key poses.
- **Linear interpolation -** Connects key poses with straight lines.
- **Keyframes** - indicates which key poses are to be connected by lines or curves.

Discussion questions (5 mins):

- **Q:** What is animation, at its core???
- **A:** Making changes to a series of images and playing those images back in sequence.
- **Q:** What are some differences between hand-drawn and computer animation? What are some similarities?
- **A:** In hand-drawn animation, animators draw key poses, then draw a series of in-betweens that connect the motion from one pose to another. In computer animation, virtual digital models are moved using posing, which is translated into coordinates that are recorded on a spreadsheet. The computer fills in the in-between images. Similarities include that they both use keyframing.
- **Q:** When animating Mr. Incredible lifting a train, changing the _____ of the spline can influence whether or not this is easy or hard for him
- **A:** the speed (or slope of the spline)
- **Q:** How is animating like acting?
- **A:** An animator brings a character to life by getting them to act through the movement of the character. Those movements create a performance that is broken down into 24th of a second increments.

VIDEO 1: Straight Ahead Animation (length: 2 mins)

Instructions: Let's start by drawing every frame, one by one. Have everyone sit where they can see the screen. From the lesson page, play the video "Straight Ahead Animation." When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Straight-Ahead Animation** - A technique where you draw one frame at a time in order, where the subject moves a little bit each time

Discussion Questions (3-4 minutes):

- **Q:** At Pixar, what is a pod?
- **A:** A group of offices in the animation department.
- **Q:** Can you think of any other spaces / places that are designed to promote creativity?
- **A:** Classroom? Studio? Theme park?
- **Q:** Can you think of any advantages or disadvantages to doing straight-ahead animation?
- **A:** Up to individuals to ponder and share

EXERCISE 1: Straight ahead animation (5-10 mins)

Instructions: Try to make an animation of a bouncing ball by positioning the ball in each frame. Click and drag the ball to position it. After students are nearly finished, here are some questions to help check for understanding before moving on to the next video:

Exercise Questions:
- **Q:** How many times can you get the ball to bounce across the frame?
- **Q**: What's the most believable speed to play it back at?
- **Q:** Go back and make minor tweaks to change the bounce (or hit clear and start over)
- **Q:** Can you make the ball roll? Bounce really crazy? Accelerate and decelerate?

VIDEO 2: Linear interpolation (length: 4 mins)

Instructions: This covers how we can connect key poses with straight lines, using linear interpolation.

Key terms / Vocabulary:
- **Key Pose** - For a bouncing ball, that's where the ball is at its highest point and where it hits the ground.
- **Breakdown** - A frame where you plan out the position of Key Poses
- **Video reference** - helps to study and learn how something moves before you animate
- **2D Timing charts** - Helps animators keep track of the inbetween drawings
- **Linear Interpolation** - connects key poses with straight lines. Results in even spacing of the poses, moving at a constant rate.
- **Axis** - Y indicates time (or frame), from left to right. X indicates height, from bottom to top

Discussion Questions (4-5 mins):

- **Q:** What is one drawback (pun intended) of straight-ahead animation?

- **A:** It can be hard to figure out where you're going

- **Q:** When a ball is bouncing downward, is it accelerating or decelerating?

- **A:** Accelerating. It Decelerates on the bounce upward

- **Q:** How can you show that a ball is accelerating or decelerating?

- **A:** Draw the ball further apart from the previous frame to show it going faster (Accelerating) Likewise, draw the ball closer to other frames when it is decelerating (climbing up slower)

EXERCISE 2: Animation with linear interpolation (length: 10 mins)

Instructions: Students should try to make a ball bounce using linear interpolation. It may be useful to demonstrate how to add keyframes first, then have individuals give it a go.

Exercise Questions:
- **Q:** How can you make the ball accelerate downwards and decelerate upwards?
- **Q:** How many keyframes do you need to make it look smooth?
- **Q:** Ask participants to share their "convincing" bouncing balls. What techniques did they employ?

VIDEO 3: Bézier curves (length: 2 mins)

Instructions: Using Bezier curves we can get smooth motion between keyframes using curved lines.

Key terms / Vocabulary:
- **Bézier curves:** Named after a French engineer, Pierre Bézier, who invented this method to describe the smooth curves needed when designing cars. Comes with handles that let you control the shape of the curve between key poses.
- **Splines:** Curved lines (Bézier curves) connecting keyframes.

Discussion Questions (2-3 mins):
- **Q:** Describe how a Bézier curve is different from linear interpolation
- **A:** linear interpolation creates equally spaced frames between key poses (creating constant speed). Where as Bézier curves allows you to control the spacing between frames, allowing you to slow down or speed up the action into or out of a pose (variable speed.)

EXERCISE 3: Animation with Bezier curves (length: 5-10 mins)

Instructions: Use the program below to create an animation of a bouncing ball. See if you can get the ball to speed up as it hits the ground. This might be fun to do as a class, or demonstrate first, then have individuals tryon their own computers.
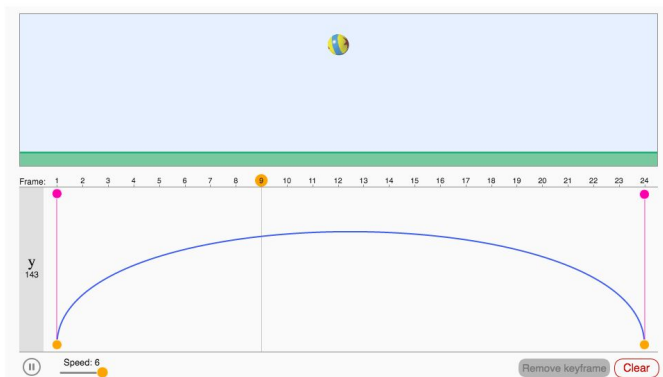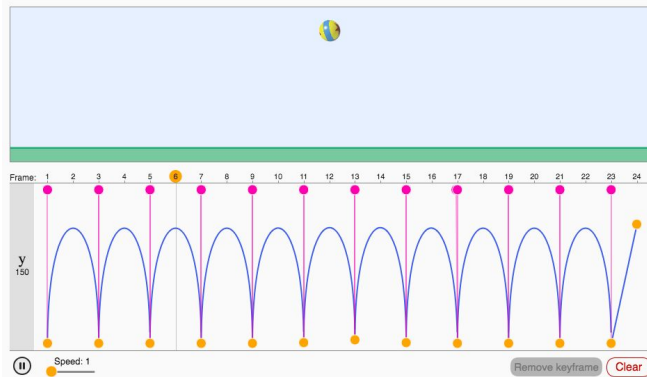
Exercise Questions:

- **Q:** What direction does the handle need to be to get the ball to speed up as it falls towards the ground?
- **A:** Vertical
- **Q:** Can you get the ball to bounce with only two keyframes?
- **A:** Yes, one at the beginning, one at the end, and position the handles vertically on each side. Playback speed should be at 6 for the most convincing bounce!
- **Q:** How many times do the balls bounce in one cycle? How many keyframes were used?
- **A:** Up to 12
- **Q:** Would anyone like to share their screens?

VIDEO 4: Squash and stretch (length: 2 mins)

Instructions: Let's breathe some life into our ball using a key animation principle: squash and stretch.

Key terms / Vocabulary:

- **Animation variables / Avars:** a control which allows you to change some aspect of your animation such as the position or size of the ball. Use the graph editor to control the timing of animation variables.
- **Squash and Stretch:** one of the [Key Principles of Animation.](#) Helps to communicate what the material of the object is made out of.
- **Anticipation:** (also a Key Principle of Animation) a short movement or action done just before a bigger action, like when Luxo Jr squashes himself down before taking a hop.

Discussion Questions:

- **Q:** What is one way you can bring an object to life?
- **A:** Show the character's thought process.
- **Q:** Who can describe the new animation variable we were just introduced to?
- Search for examples of squash and stretch online, then share.

EXERCISE 4: Squash and stretch animation with Bezier curves (length: 10-15 mins)

Instructions: Use the program below to create an animation of a bouncing ball. See if you can get the ball to squash as it hits the ground and stretch as it bounces back. Pick an emotion that your ball might be feeling. How can you show that using squash and stretch?

Exercise Questions:

- **Q:** What kind of ball do you want to animate? What's it doing? What's it thinking? How might you bring it to life?
- **Q:** What number for the Avar (s) makes the ball stretched tall?
- **Q:** 100
- **Q:** What number for the Avar (s) makes the ball squashed?
- **A**: 0
- Q: Share the various ways you can make this ball come to life.

Practice: Animation 101 (length 10-15 mins)

7 problems covering some key concepts

- Y and X axis (Y is height above ground, X is time in frames)
- Interpolation types (Linear is constant, Bezier is curved)

Check for questions before moving on as a group to the next video.

VIDEO 5: Getting to know Rob Jensen (length 3 mins)

Instructions: *How did Rob start out?* Have everyone sit where they can see the screen. From the lesson page, play the video "Getting to know Rob Jensen." When the video ends, start a discussion with your group using questions below.

Discussion Questions:

- **Q:** What inspired you about Rob's journey?
- **Q:** How could you start out becoming an animator? Are there any classes you can take to study computer science, drawing, acting, sculpting, storytelling or painting?

Optional Activity Idea:

- Rob has a thinking face, along with a little sound he makes when he's thinking. What's your thinking face? Do you also have a sound you make?

Save your Animation: (length 20-30 mins)

Instructions: Make and save your own animation! Use the program on this page to build your animation. Now you can move the ball anywhere as well as rotate it! Can you make the ball look heavy, or like a water balloon? Can you make it look happy?

- Use the **x** and **y** avars to position the ball.
- Use the **s** avar to control the stretch and squash.
- Use the **r** avar to control the rotation of the ball.

Optional: When you're happy with your animation press the Save button; this will bring up a black box containing the code for your animation.

Copy all the text in the box and paste it here to create a new program. Then save that program to your Khan Academy learning profile.

Known Bug!: If you see an X and several A's on the last two lines, delete those.

- Give your animation a title.

If you'd like to explore this further, we have an hour long hands-on activity that extends this lesson here:

Hands-on activity: animating Luxo Jr. (30-90 mins)