

Vector-Based Animation

- What is a Vector?
- Uses of Vector-Based Animation
- Introduction to Flash Professional

What Is A Vector?

Images are created using **vectors** rather than **pixels**.

Vectors are mathematical equations saved and rendered by the GPU.

When saving a vector, we want the **smoothness** of curves while also being able to control the **rigidness** and **sharpness** of certain edges.

So what does this look like in memory?

$$p(t) = at^3 + bt^2 + ct + d$$

Sets of **piecewise cubic polynomials** are enough to render complicated graphics in both 2D and 3D.

We use the GPU to make **thousands of calls** to compute these cubic polynomials over a **finite yet large number of time intervals** to approximate the curve. Hence, vectors are **infinitely scalable**. For higher resolution, make more calls on a larger number of intervals.

What Is A Vector?

So why piecewise cubic polynomials?

$$p(0) = p_0 \Rightarrow d = p_0$$

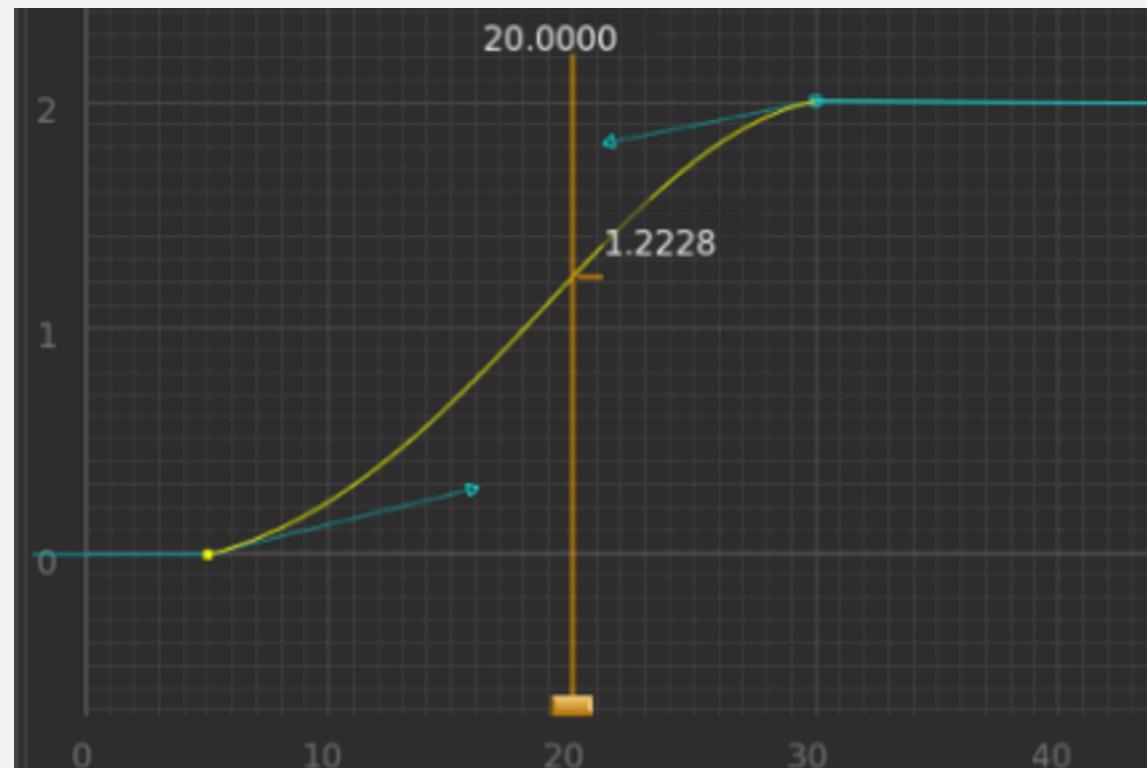
$$p(1) = p_1 \Rightarrow a + b + c + d = p_1$$

$$p'(0) = u_0 \Rightarrow c = u_0$$

$$p'(1) = u_1 \Rightarrow 3a + 2b + c = u_1$$

Cubic polynomial coefficients can be broken down into their **keyframe and tangent components**. As an animator, we specify where we want a segment of our curve to start, where to end, and the tangents at those points. This gives us 4 constraints that can be turned into 4 coefficients of a cubic polynomial for the computer to solve.

Animation is just a math class. Have I convinced you yet? No? Well let's keep going then.



What Is A Vector?

Vectors give us free control of how we want our curves to look.

Keyframes always match from one piecewise cubic to the next. This gives us C0 continuity.

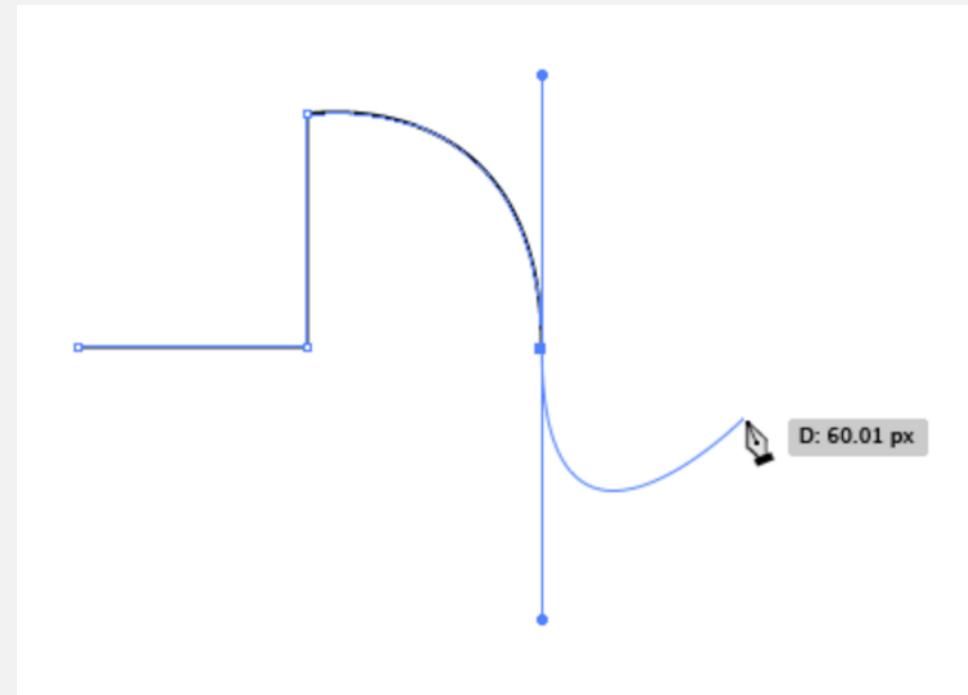
C0 continuity – keyframes are continuous

C1 continuity – first derivative is continuous

C2 continuity – second derivative is continuous

By default, most applications will also have the **tangents at each keyframe match**. This gives us C1 continuity. We can break this by individually modifying tangents to point in different directions.

Vectoring is the act of **placing keyframes and modifying tangents**. The entire infrastructure of Adobe Illustrator is built on vector primitives which we will see more of later.



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Vectors In Animation



Vector Puppet Rigging

Characters are of vector assets thrown together to make a puppet.

Question is where to start dividing a puppet into separate vectors.

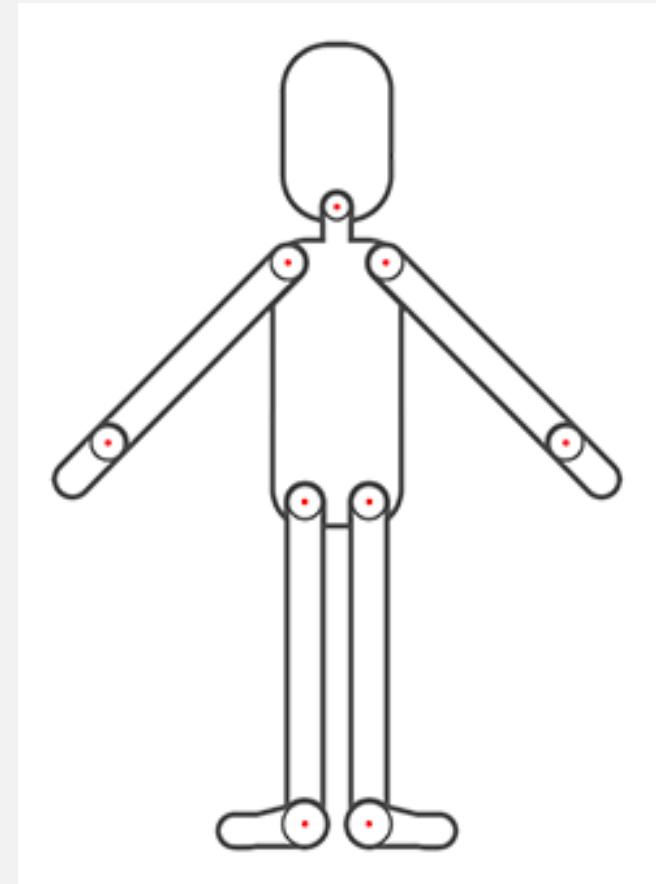
More vectors = More mobility = Harder to keep track of.

General rule: Separate vectors of puppets based on **principal joints**.

In humans, that means keeping a vector for head, neck, body, torso, upper arm, lower arm, hand, upper leg, lower leg, and foot.

This is just a general guideline. The joints are **heavily influenced based on character's body type and motion**. If they will be moving a lot in a certain area, have more joints in that area.

Puppet creation/rigging is an extensive field in character design and isn't covered in this course.



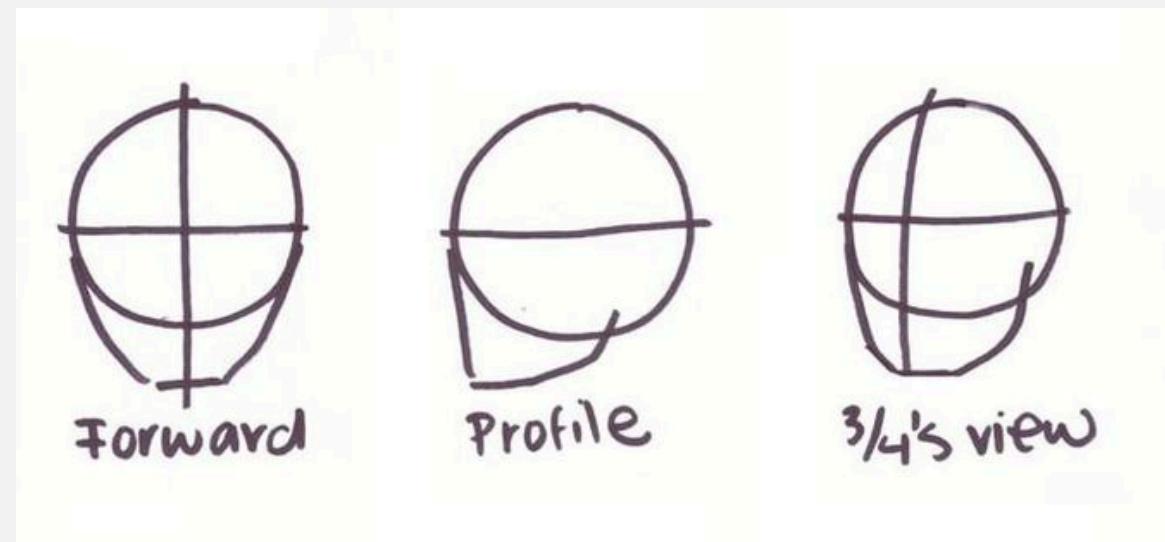
Puppeting From Different Angles

3 important views to consider: **Front, Profile, and ¾ (or 3Q) view.**

Character assets for puppets are built into one of the above three categories. We can **flip the views across the vertical axis** to get rotations in the other direction.

2 additional views to consider: **Back** and **Back ¾ (or 3Q) view.**

5 Views are enough to capture dynamic range of character angles



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Flash Professional

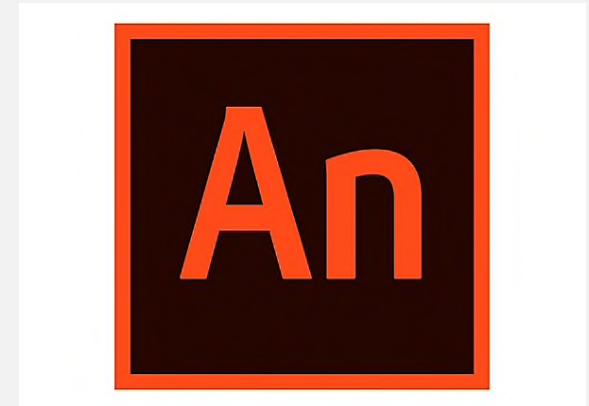
Adobe Flash Professional is a software used for **creating and animating 2D vectorized puppets.**

High integration with other Adobe apps. So if you don't like Flash Professional's vectoring interface (which is somewhat different), you can create and import vectors from another Adobe product or from Adobe Stock.

With the release of CC, has **dark theme.** 

Flash Professional can **export animations to .swf format** readable by flash-contained browsers, or easily imported into other apps for video editing and post-processing.

Flash Professional is **not a stand-alone app.** Works best with other post-processing software that can export to many other compatible and mainstream formats.



Renamed to Animate in Early 2016.

Flash Professional

Keyframing, Tweening, Layering

Time and Interpolate motions here. General rule-of-thumb is that each layer should have one symbol, or else tweening won't work.

Selection, Fill, Draw, Erase, Vector Tools

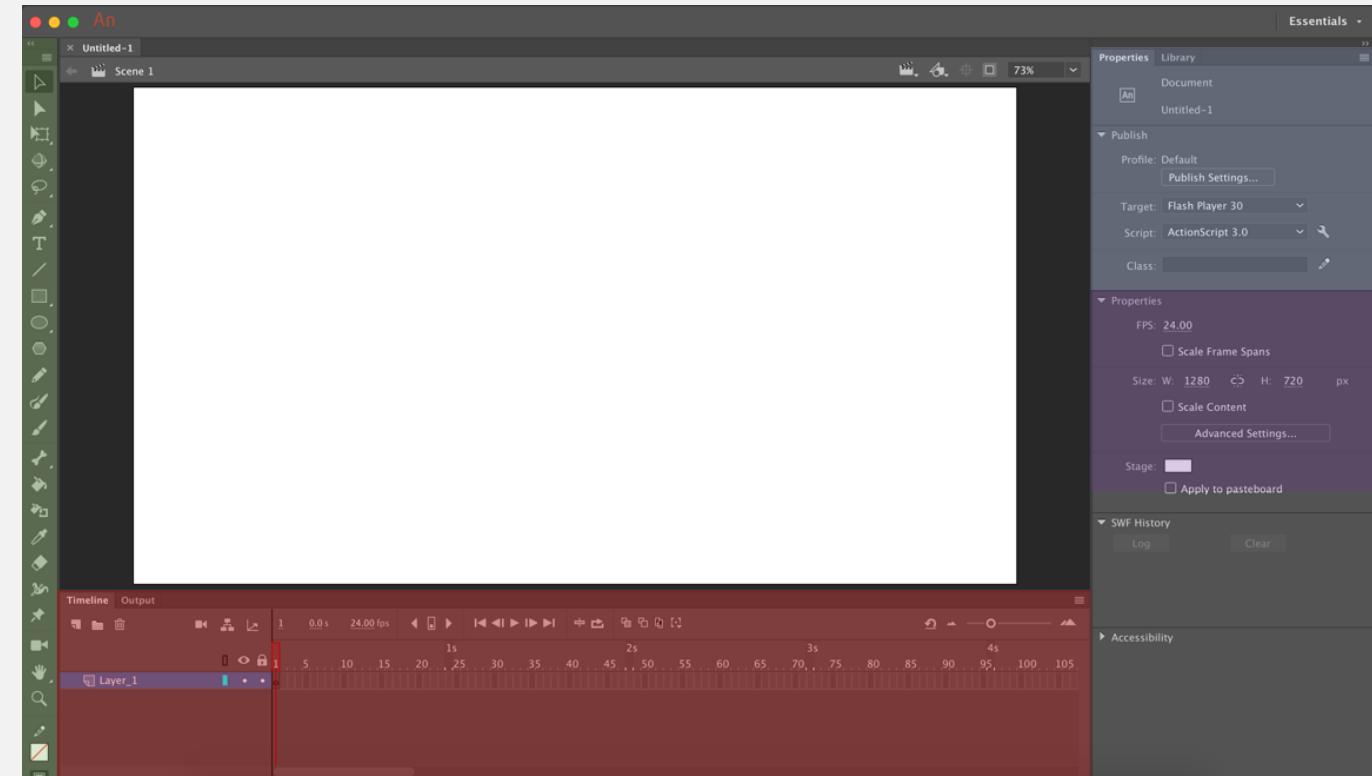
Main tools for creating and modifying vector primitives.

Symbol Grouping, Layer Styles

Merge together primitives into symbols that can be modified as a rasterized group.

Transformation Properties

Apply transformations to symbols and objects at keyframed time-intervals.



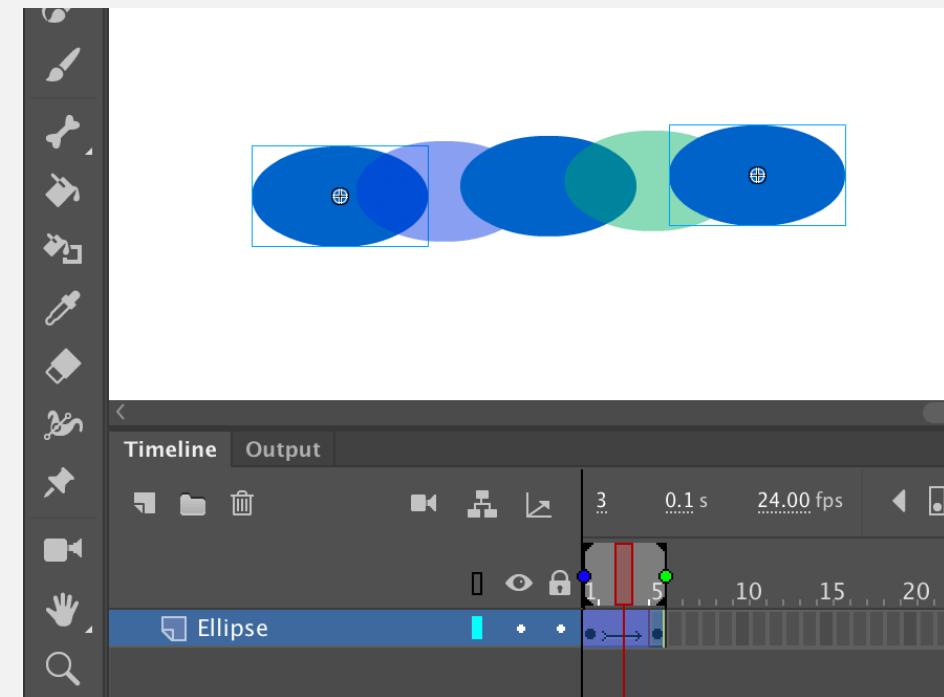
What is a Tween?

Short for **in-between**. Signifies the frames between two key animations.

Tweening was practiced before computer animation automated it. **Senior animators** would draw out the key frames of an animation, and more **new or inexperienced animators** would be trusted with drawing in the in-between frames.

This is how we get the name **keyframe** and **tween**.

Tweening attempts to solve how an animation should look in between two keyframes. A defining characteristic of tweening is **interpolation**, which is the path and speed that the object takes to get between two keyframes.



What Makes a Tween Unique?

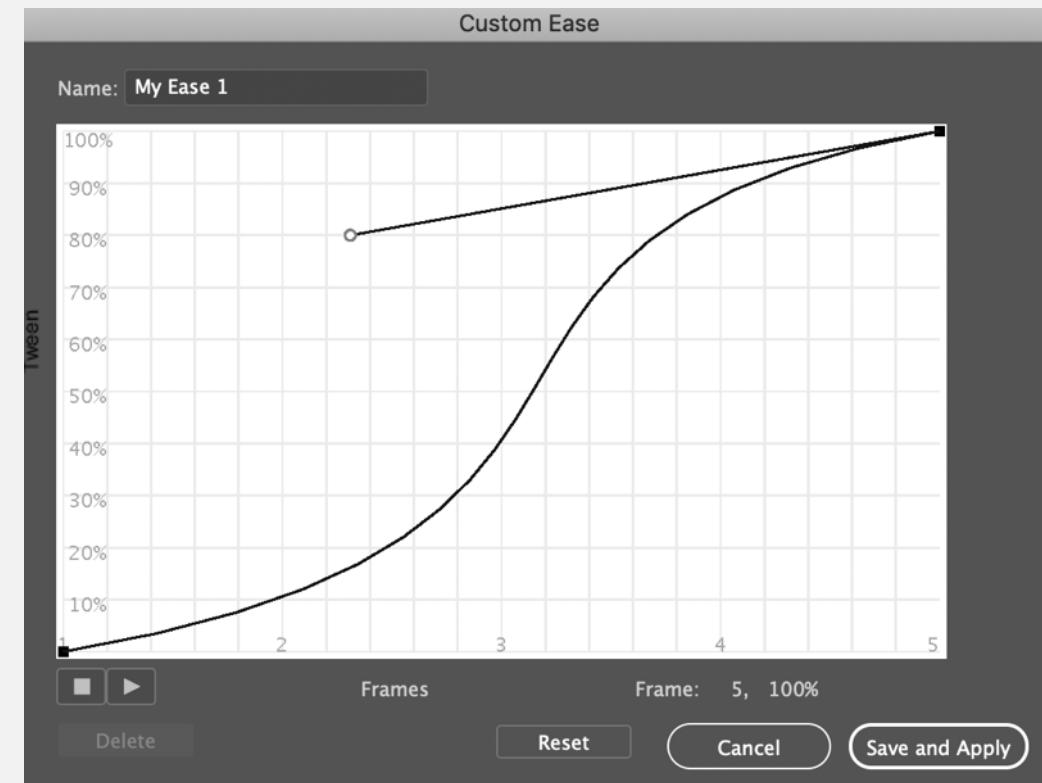
Tweens are characterized by a **change in value**, a **change in time**, and an **interpolation**.

Any two tweens with the same three properties are considered to be the same.

Interpolation specifies the **change in motion over time**. It can often be related to the acceleration of an object.

Interpolations are customizable and often represented as a **cubic polynomial**.

Tweens are large components of vector-based animations. Since vector locations are saved as mathematical quantities, we can calculate transformations of vectors just as easily as rendering them.

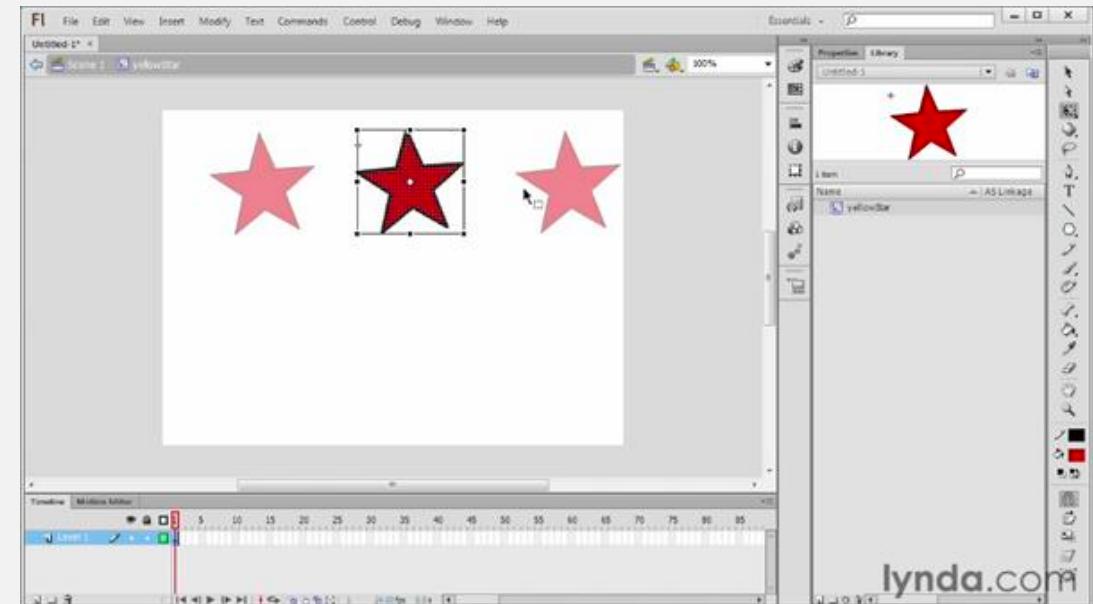


Symbols

Symbols in Flash are a way to **group vectors together**. Normal vectors cannot have transformations applied to them and must be converted to a symbol first.

Different vectors can have a **hierarchy of symbols**. A nose can be a symbol of the face which in turn can be a symbol of the head.

This allows the face to have its own animation cycle independent of the head. Whatever animation the head has, the face will follow, while adding its animation cycle on top of the head's cycle. This idea of recursively applying parent transformations to the child is common in any group-based hierarchy.



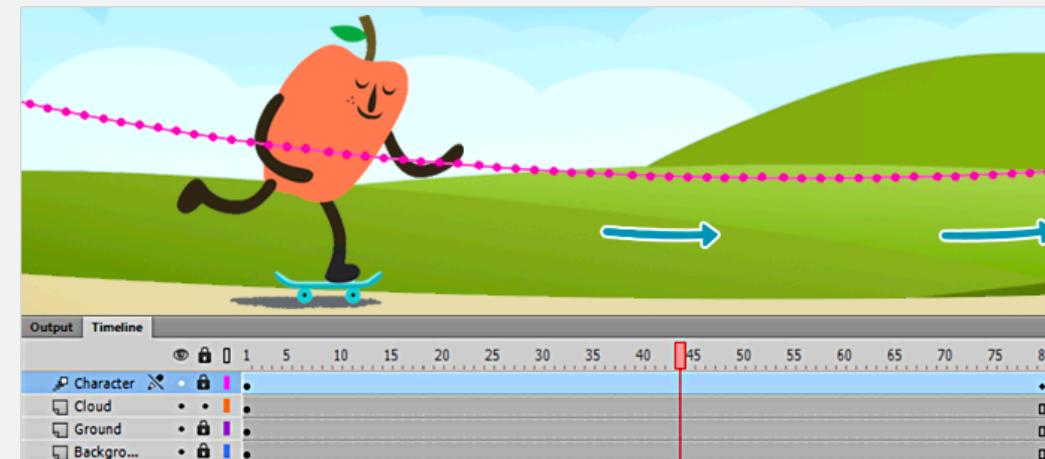
Transformations

Flash Professional has a **Transformation Editor** tool that can be used to edit any one of the following parameters:

- Position
- Rotation
- Scale

Position by default will spatially interpolate linearly but can be configured via **guide layer** to interpolate over curves.

Opacity, color, and other style properties can be animated using the **Properties Tab**.



Anchor Points

An Anchor Point defines around what **point-of-origin** an object will rotate/scale about.

For rotation, think of it as sticking the image against the wall with a tack at the location of the anchor point. Notice how the image rotates around this point.

For scale, the image grows away/shrinks towards the anchor point.

Anchor Points are animate-able properties too! We will see more of this when we get to After Effects



Homework

- ❑ Create a basic puppet with a few distinct vector components (Several primitives is fine).
Arrange them properly using symbols.
- ❑ Create animation cycles for these components on the timeline.
- ❑ Use the graph editor to edit the temporal interpolation values to accommodate for easing.
- ❑ Upload your .fla files to the course Drive.

Questions?

Live Demo