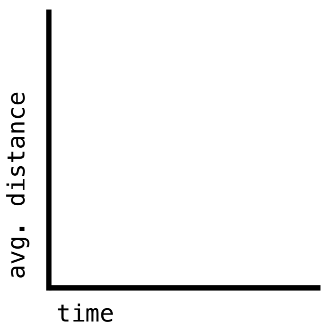
bigbanger.jacobford.com



On the scale of the universe, galaxies are treated like the molecules of terrestrial physics. When modeling possible expansion patterns of the entire universe, these multi-lightyear clusters of human-imperceptibly large objects are blackboxed into particles, and all that is measured is the space between them, so that the history of the universe—the history of everything we know and are physically able to experience and everything that has ever been experienced—can be represented two variables: R, for the average distance between galaxies, and T, for time.

The people at the World Wide Web Consortium (W3C) have a similar, but opposite, problem. Rather than being presented with everything knowable, then figuring out the processes and elements by which it was made, the W3C must create the processes and elements by which anything *can* be made. These are the people who author the official standards for hypertext markup language (HTML) and cascading stylesheets (CSS). They control the syntax of the languages in which the Internet is written.

Interesting parallels exist between web design and cosmology, making the former a surprisingly useful tool for modeling and understanding the second. In HTML, an

<element>

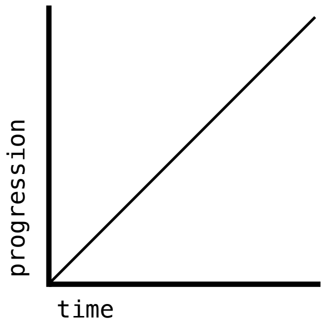
element is a single rectangular object which exists within a web document's structure. Nothing can exist on a webpage if it is not contained in some element, not unlike the elements of the tangible world, out of which everything is made. In web design, attributes and styles are assigned to elements using a system of classes and IDs. Multiple elements may share the same class, and multiple classes may be assigned to one element, but an ID must be unique to an element, and each element can only have one ID. In the The Big Banger, galaxies are all assigned the class "galaxy" so that they may all be formatted as identical dots with one set of styling rules which apply to the entire class. The universe, however, the parent element which contains all galaxy elements, is assigned an ID of "universe," because there will only be one universe in this document.

```
.class
#id
```

The parallels only get more useful and metaphysically freaky with the animation of elements' attributes, a relatively new suite of rules and properties authored by W3C in 2009.[1] CSS animations allow the web designer to specify any two numerical values for an element (be it color, position, size, etc.): where it should start and where it should end. then have the web browser interpolate those values so the element passes through every value in between over a specified period of time.

```
from {
  width: 10px;
}
to {
  width: 20px;
}
```

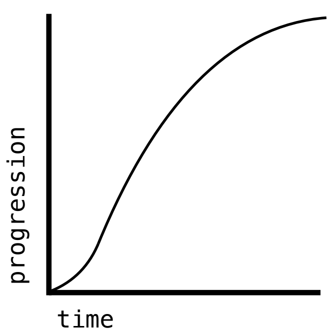
[1] see CSS Animations Module Level 3: W3C Working Draft 20 March 2009



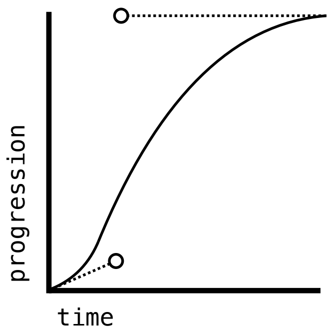
The simplest and most intuitive way to do this is a linear change in attribute values, from the animation's beginning to the ending state, but this actually produces a very abnormal animation for humans, especially when the attributes being animated are the element's size or positioning on the page. Because velocity in the physical word can never jump from one value to another without passing through every value in between, a linear transition between an element's values appears lurching and unnatural. To combat this, CSS transitions are controlled using timing functions, also known as easing functions.

```
animation-timing-function: ease;
```

If none is specified, the default timing function (nicknamed *ease*) defines a function which mitigates some of the lurching by smoothing out the beginning and ending of the interpolation. The lower-left corner of the graph represents the element at its beginning state, and the upper-right represents the ending state. The curve defines what attribute value(s) the element should have at any specific moment throughout the duration of the animation.



Easing functions are placed on a graph ranging from zero to one on both axes, and described using cubic beziers, which allow a curve to be defined by four coordinates: its starting point, the point it begins by going toward, its ending point, and the point it approaches the end from. The starting and ending points are already determined: (0,0) and (1,1), because the animation must begin at its starting state at zero time and arrive, the the ending time, at its ending state. The two points which must be defined are are the “going toward” and “coming from” points. For the default *ease* timing function, these points are defined as (0.25,0.1) and (0.25, 1).[2]




```
animation-timing-function: cubic-bezier(.25,.1,.25,1); /* ease */
```

These graphs are oddly similar to the simple models of the universe’s expansion described earlier. Both have an x-axis of time, and if the expansion of the universe can be imagined as a transition of every galaxy from a single point for all to a unique “edge of the universe” for each, the y-axis will correlate to the average distance between galaxies. The only remaining factor is the cubic bezier of the universe.

It turns out this is roughly determined by Ω, the ratio of the universe’s actual density to the minimum density which would prevent it from expanding forever.[3] The value of Ω determines the speed at which the universe expands over time, essentially determining the easing function of

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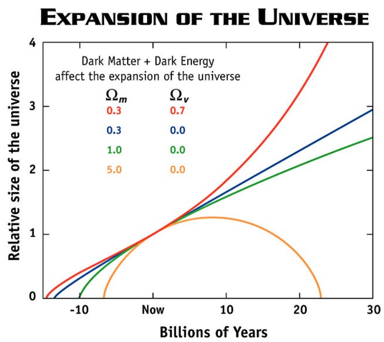
[2] see CSS Transitions: W3C Working Draft 19 November 2013

[3] it’s unclear who first defined Ω, but its terms (ρ and ρ_c) were first described by Alexander Friedmann in *Über die Krümmung des Raumes*, published in *Zeitschrift für Physik* 10, 377–386 (1922). A translation into English by F. R. Ellis and H. van Elst was published in *General Relativity and Gravitation* 31, 1991-2000 (1999), titled *On the Curvature of Space*.



the universe. The blue, green, and yellow lines in the diagram at left (via NASA) show what the expansion of the universe would look like if the value of Ω is less than, equal to, or greater than one, respectively. The red curve, which increasingly seems to be the correct one, defines a universe where the value of Ω matters less[4] because of some unknown energy accelerating the expansion of the universe over time.[5] These curves look astoundingly like cubic beziers, and I was able to quickly write four to estimate the curve of each expansion model.

```
animation-timing-function: cubic-bezier(0,.04,.26,.26); /* omega lt 1 */
animation-timing-function: cubic-bezier(0,.11,.44,.44); /* omega =  1 */
animation-timing-function: cubic-bezier(0,0,.58,1);     /* omega gt 1 */
animation-timing-function: cubic-bezier(0,.19,.95,.52); /* omega ?  1 wde */
```

Relative to each other, each *would* begin at different times, and CSS *does* include a useful transition-delay property, which determines an amount of time to wait before beginning the animation. But because each universe would be the entire reality while it is running are not being simultaneously, I simply began each bang at the exact same moment, when the user selects an Ω value.

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[4] Or, at least, it's unclear if the "dark energy" constant should be kept separate from Ω or factored into it. A wonderfully titled paper, *Adventures in Friedmann cosmology: A detailed expansion of the cosmological Friedmann equations*, by Robert J. Nemisroff and Bijunath Patla published in the *American Journal of Physics* 76, 265–267 (2008) includes them. NASA, it appears, keeps it separate.

[5] Einstein, whose theory of relativity predicted an expanding universe, was sure the universe was stable, so he arbitrarily added a constant (λ) to his equation to keep the universe stable. When Hubble observed redshift on distant galaxies and proved the universe *was* expanding, Einstein called it his "biggest blunder." Now, as more detailed redshift data show galaxies aligning to the accelerating expansion curve, λ is becoming useful again to represent whatever mysterious force pushes galaxies away faster as time goes on. I imagine similar internal battles at W3C over the formula for the ideal easing curve.

Still, the yellow curve ($\Omega > 1$) is special; it needed to ease to an expanded state, then reverse itself back to the start. The wonderful people at W3C were prepared with a CSS rule that tells the web browser to do just that.

```
animation-direction: alternate;
```

This particular scenario is called the Big Crunch model, and depending on the calculator's beliefs in math, could continue banging and crunching ad infinitum. And once again,

```
animation-iteration-count: infinite;
```