“Random”

What is Randomness?

“The quality or state of lacking a pattern or principle of organization; unpredictability.”

What is (Mathematical) Chaos?

“When a deterministic system appears random due to its extreme sensitivity to initial conditions.”

Are Computers Random?

Not Technically*

*Usually

On The Randomness of Computers

Without specialized hardware,
computers cannot generate true random numbers.

By design, computers are deterministic.

Nature is not.*

*Unless we live in a deterministic universe.

Examples of True Random

- Radioactive Decay
  - This is why the rate of decay is measured in half-life, not time per emission.
- Atmospheric Noise
  - You can hear this as radio static.
- Heat and Fluid Dynamics* (effectively)
  - Lava Lamps

Examples of Pseudo Random

- Minecraft World Generation
  - This is why the same seed generates the same world.

- Most Random Number Generators
  - Your computer uses algorithms to make a very long sequence of chaotic numbers.
  - This sequence WILL repeat.
  - Modern PRNGs take an astronomically large number of generations. For example: Mersenne Twister: 2^{19937} -1
  - Older PRNGs only had a period of 2.15 billion.

So We Are Talking
Pseudo Random

`random()`

- PRNGs generate “effectively” random numbers.
- We can treat them like white noise.
- p5’s `random()` function is a good example.
  - Returns a random number between 0.0 and 1.0

Molding Random

- Uniform random is solid, but there are other forms of randomness we might want.

- Some frameworks have functions built in for other types. Sometimes we need to make them ourselves.

- We can make all sorts of randomness using functions like `random()`.

Non-Uniform Random

- Values are chosen on a non-uniform distribution.

- A lot of different ways to apply this.

Custom Distributions

- Using randomness to make non-uniform decisions.

- We might say “1 in every 5 pixels should be red. The rest should be randomly grayscale”.

Normal or Gaussian Distributions

- Pick random values clustered around a point.
- In 1D, this makes a bell curve.
  - Well technically a curve is 2D but you know what I'm saying. The points would be distributed in a bell curve… You know what, forget it.
- Some tools have this built in, such as p5's randomGaussian()

A JavaScript Gaussian Implementation

It is based on the Box-Muller Transform.

Yes, you can simplify this. This version is meant for readability.

```
function randGaussian(mean = 0, sd = 1) {
  let u1 = random();
  let u2 = random();
  let z0 = sqrt(-2 * log(u1)) * cos(TWO_PI * u2);
  return z0 * sd + mean;
}
```

Exponential Distributions

- Have a decaying likelihood of choosing a given number.
- In 1D, this makes a decaying curve.
  - ☝🤓 “Erm ackshually, a curve is 2D!” 😐 “I know…”
- This is less commonly implemented, but is easy to add ourselves.

A JavaScript Exponential Implementation

Yes, you can simplify this. This version is meant for readability.

```
function randExponential(lambda = 1) {
  let u = random();
  return -log(1 - u) / lambda;
}
```

Eased Distributions

- Realistically the exponential distribution is just an application of one easing function to a random input.

- There are plenty of easing functions we could use.

- https://easings.net/

Smoothed Random

- Rather than actually random values, we have values related to previous values with random fluctuation.

- In 1D, this makes a squiggly line.
  - 🙂

- Perlin Noise, Simplex Noise, Fractal Brownian Motion…
  - Many tools have at least one of these.

Applications of Random in Art

- Vary properties such as position, color, size, speed, etc.
- Making decisions and selecting from a set of options.
- Creating organic and natural effects.
- Creating emergent complexity.

Assignment:

Randomness + _____