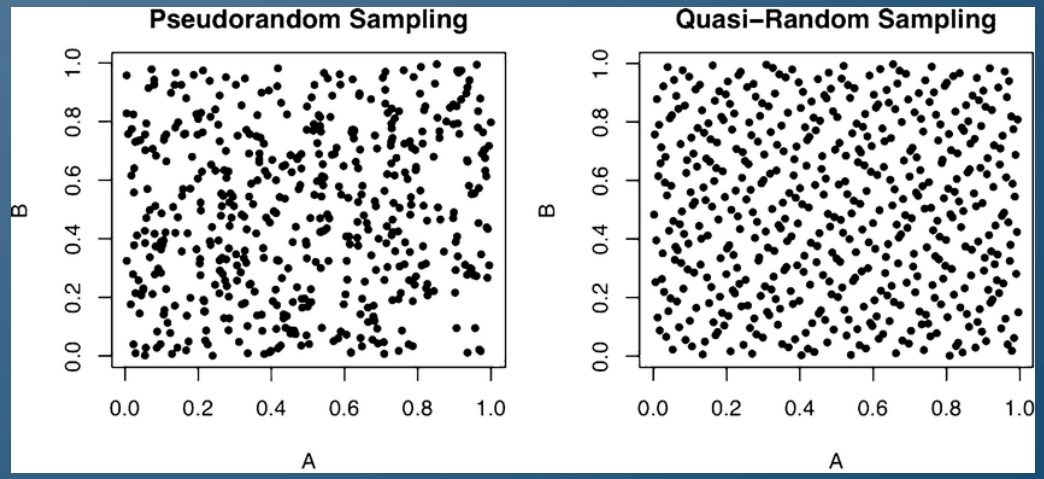
PROCEDURAL GENERATION

BASICS OF RANDOMNESS

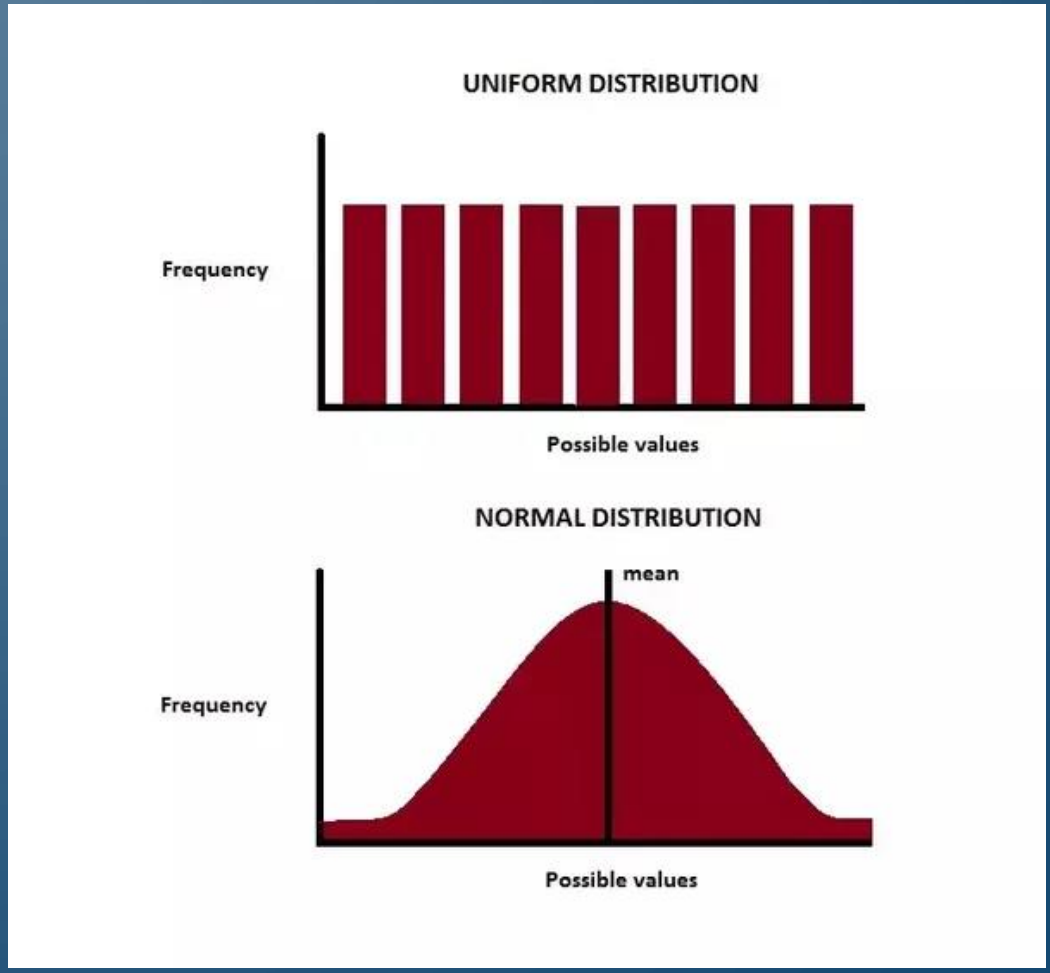
GENERATING RANDOM BITS

- Random bits are generated from **pseudorandom number generators**, or algorithms that generate a sequence of bits that appears random
  - Sequence based on a "seed" that starts the algorithm off
  - Set of bits are composed and manipulated to interpret higher level types, e.g., integers or floating-point numbers
- Numbers can also be generated through quasi-random or truly random generation (quantum computers)



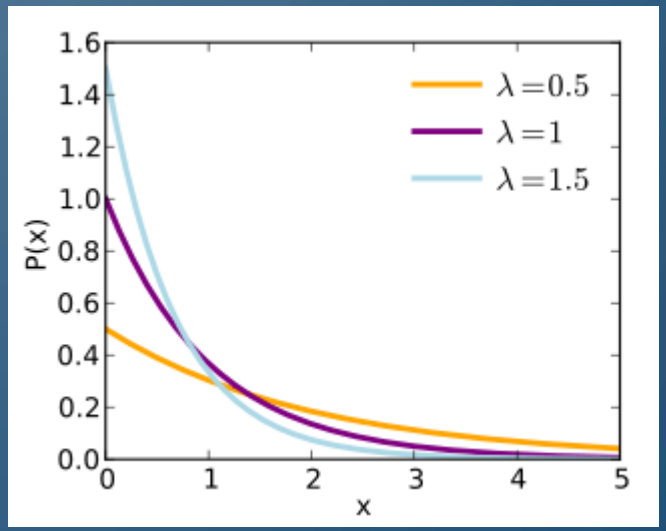
VARIOUS DISTRIBUTIONS

- Random numbers are manipulated so that they then reflect a probability distribution
- Uniform distribution – all values equally likely in a range (or discrete set)
- Gaussian distribution – values near a mean are more likely than far away from a mean



VARIOUS DISTRIBUTIONS

- Binomial distribution – series of coin flips
- Poisson distribution – expresses probability of a given number of events occurring within a time interval
- Exponential distribution – represents time between different Poisson events
- Etc.



EXERCISE

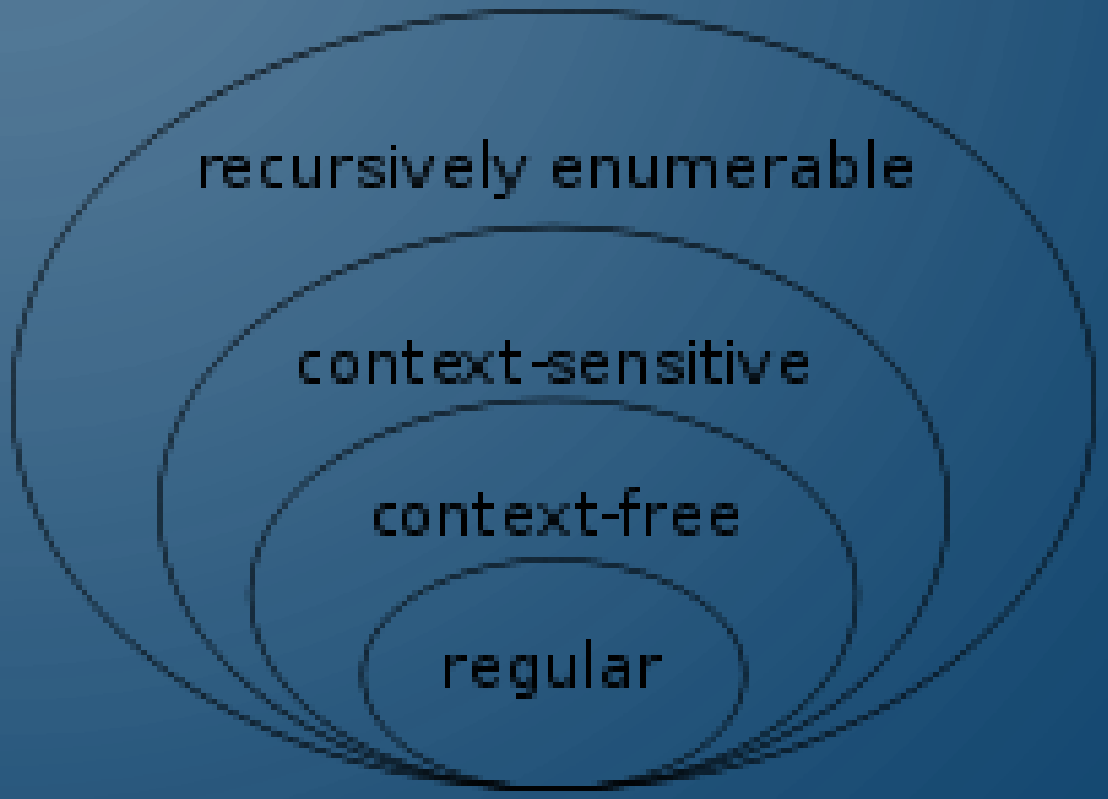
- With a partner
  - Define an algorithm to generate points uniformly within a disc of radius r
  - Define an algorithm to generate velocities biased towards a target velocity for a series of objects
  - Where in games you have played have you seen this most basic form of generation?

GENERATIVE GRAMMARS

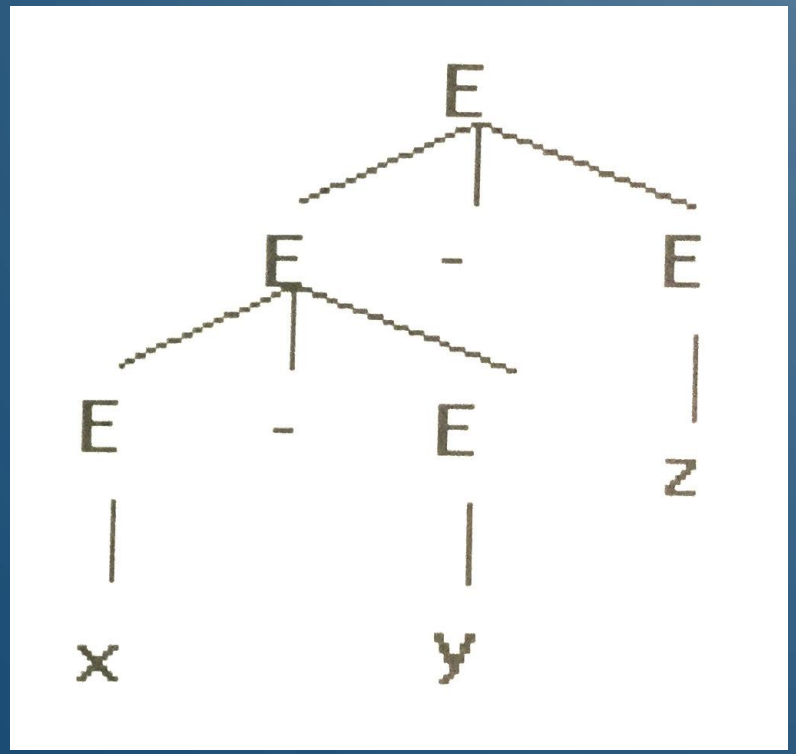
WHAT'S A GRAMMAR?

- A set of production rules for strings in a language
- Example: all strings containing at least one "a" followed by the same number of "b"s
  - "ab", "aabb", etc
  - Production rules:

$$S \leftarrow aSb$$
$$S \leftarrow ab$$



HOW CAN THESE BE USEFUL FOR GENERATING CONTENT?

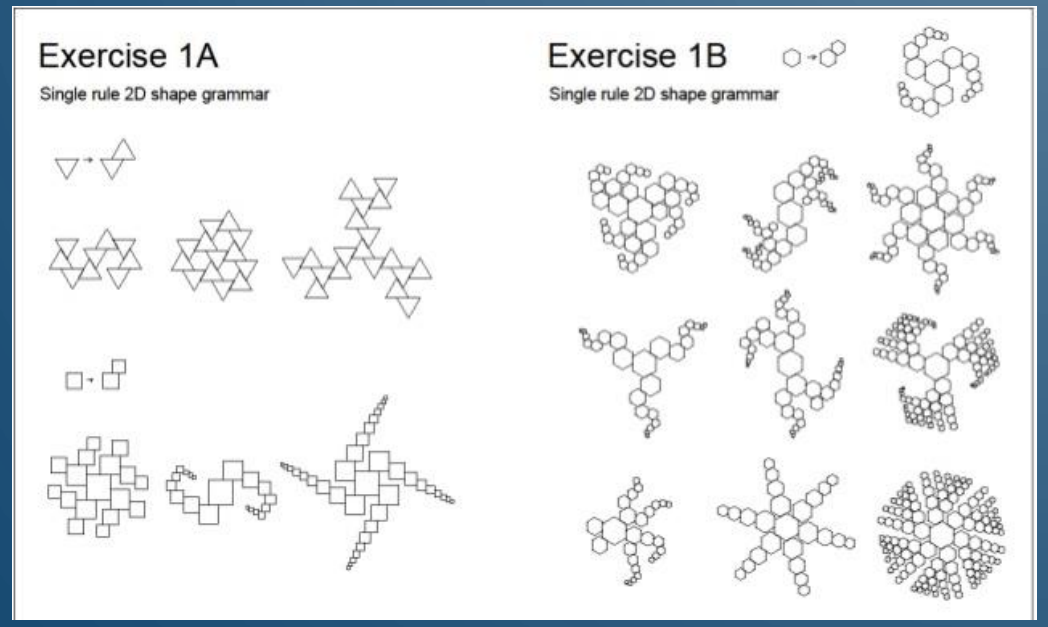


- Expressed as a **generative grammar**, they define rules to generate strings in a language, vs "accept" strings in the language
- Simple procedure could be to uniformly pick a production rule repeatedly to generate a random string from the language
  - Essentially forms a random grammar tree
  - Can apply constraints and non-random decision making as well

LINDENMAYER SYSTEM

- Combines generative grammar of strings with a translation system to translate the string into geometric structures

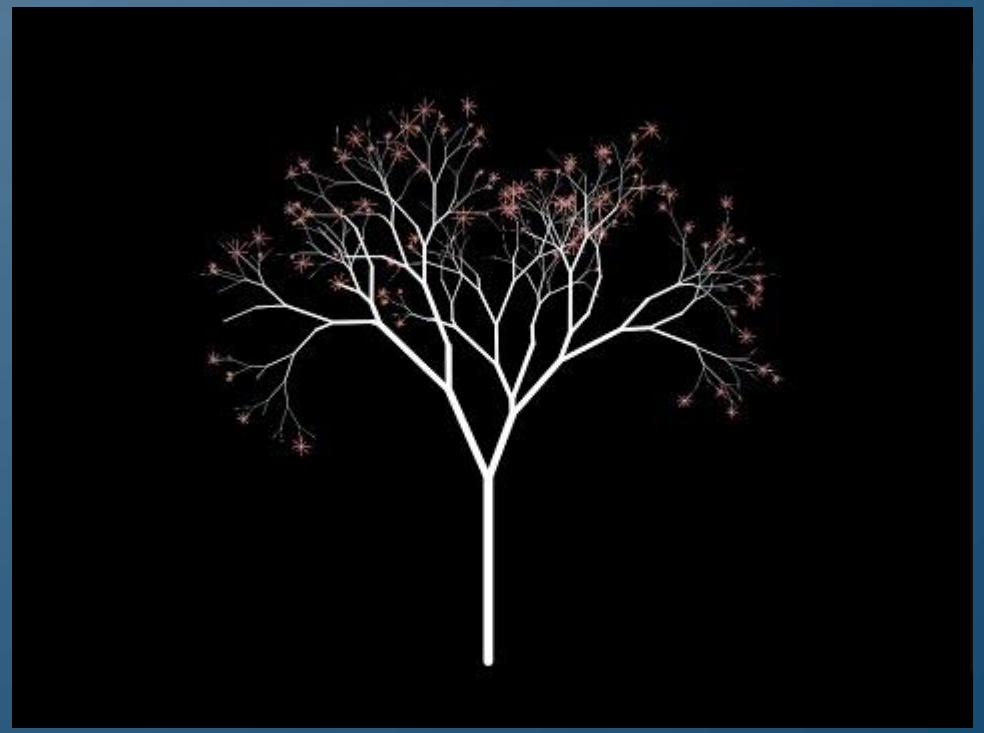
SHAPE GRAMMAR



- Production system to generate a geometric shape
- Rules describe how an existing part of a shape

ADVANCED METHODS FOR PROCEDURAL GENERATION

- Image filtering
- Spatial algorithms
  - Fractals
- Simulation and modeling
  - Cellular automata
- AI
  - Genetic algorithms
  - Neural networks



HOW DOES PROCEDURAL GENERATION COME INTO PLAY IN YOUR GAME CONCEPTS?

SUMMARY

- Procedural generation can greatly enhance the user experience and re-playability of a game
- Many methods can be employed at all levels of game content

EXAM

- Closed note/book exam
- No questions on Unity
- Format – five sections and a bonus
  - Q1 – T/F – Definitions/Concepts from FGD
  - Q2 – Fill-in-the-blank – Definitions/Concepts from GPAT
  - Q3 – Free response – Game programming (Game loop, input, sound)
  - Q4 – Free response – Game programming (Graphics, camera models, and procedural generation)
  - Q5 – Free response – Analyze design decisions
  - Bonus – ?