Java: Class Random

```
private AtomicLong seed;
private final static long multiplier = 0x5DEECE66DL;
private final static long addend = 0xBL;
private final static long mask = (1L << 48) - 1;

protected int next(int bits) {
    long oldseed, nextseed;
    do {
        oldseed = seed.get();
        nextseed = (oldseed * multiplier + addend) & mask;
    } while (!seed.attemptUpdate(oldseed, nextseed));
    return (int)(nextseed >>> (48 - bits));
}

public int nextInt() {  return next(32); }
```

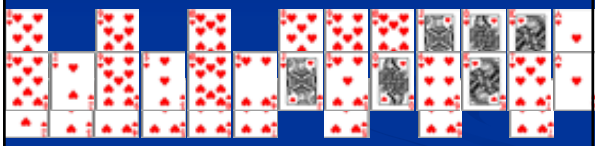
Random shuffling

- generate random permutation, where all permutations have a uniform random distribution
- shuffling ≈ inverse sorting (!)
- ordered set $S = \langle s_1, \ldots, s_n \rangle$ to be shuffled
- naïve solution
  - enumerate all possible $n!$ permutations
  - generate a random integer $[1, n!]$ and select the corresponding permutation
  - practical only when n is small

Random sampling without replacement

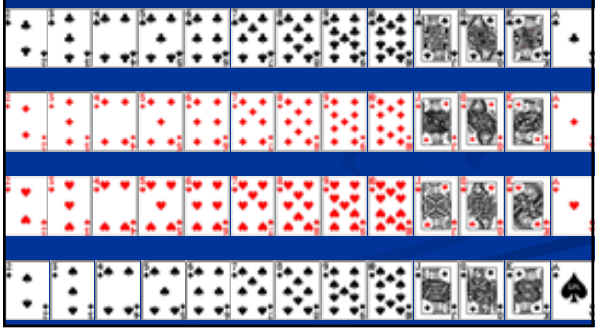
- guarantees that the distribution of permutations is uniform
  - every element has a probability $1/n$ to become selected in the first position
  - subsequent position are filled with the remaining $n - 1$ elements
  - because selections are independent, the probability of any generated ordered set is $1/n \cdot 1/(n-1) \cdot 1/(n-2) \cdot \ldots \cdot 1/1 = 1/n!$
  - there are exactly $n!$ possible permutations → generated ordered sets have a uniform distribution

Riffle shuffle



Perfect shuffle

Premo: Standard order



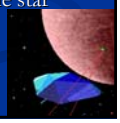
Premo: After a riffle shuffle and card insertion

Random numbers in games

- terrain generation
- events
- character creation
- decision-making
- game world compression
- synchronized simulation

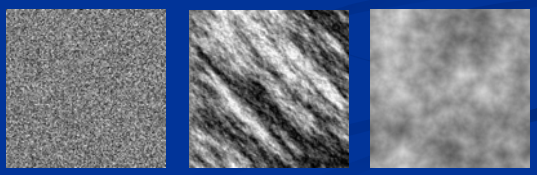
Game world compression

- used in *Elite* (1984)
- finite and discrete galaxy
- enumerate the positions
- set the seed value
- generate a random value for each position
  - if smaller than a given density, create a star
  - otherwise, space is void
- each star is associated with a randomly generated number, which used as a seed when creating the star system details (name, composition, planets)
- can be hierarchically extended



Terrain generation 1(2)

- simple random
- limited random
- particle deposition



Terrain generation 2(2)

- fault line
- circle hill
- midpoint displacement