9.2 Simulations

Simulations

- We think of a model as a set of equations describing what we observe in a real-world experiment.

- When we can’t even do the experiment (e.g., nuclear testing), the model can be considered a simulation.

Monte Carlo Simulations

A Monte Carlo simulation is a probabilistic model involving an element of chance.

Genesis of Monte Carlo Simulations

John(ny) von Neumann

(1903-1957)

- Game theory
- Quantum mechanics
- Economics
- Cellular automata
- Nuclear weapons
- Computer science (“von Neumann bottleneck)

(Pseudo)Random Numbers

- True randomness is rare (radioactive decay)
- In practice, we mimic randomness with a deterministic process
- Linear congruential method uses modulus (clock) arithmetic to generate a sequence *r* :

$r_0 = 10$

$r_n = (7\ r_{n-1} + 1)\ mod\ 11$, for $n > 0$

Linear Congruential Method

- In general:

  $r_0 = seed$

  $r_n = (multiplier * r_{n-1} + increment) \bmod modulus$, for $n > 0$

- Much research is devoted to methods for making these sequences difficult to predict (*e.g.,* for codebreaking)

- Periodicity (length before repetition) should be as large as possible.

Different Ranges of Random Numbers

- May want to restrict range of numbers, get floating-point values, etc.
- Modulus tells us the maximum integer we'll get. So we can divide by that max to get a floating-point value *r* in the interval [0,1].
- We can then rescale to a new min, max:

  $s = (max - min) * r + min$