Computer Simulation: Fake it till you make it
“Everything is a circuit…”

- In the early 20th century, engineers found it convenient to represent mechanical systems by electrical circuits.
- This was possible because the same math represents resistors/capacitors/inductors and springs/dampers/masses.
- What math?—Differential Equations (linear constant coefficient differential equations).
- Inputs and outputs and states (boxes and arrows).
Analog Models

- Basic idea: build a circuit model, and then test its response (electrically) using a signal generator and oscilloscope—to learn about mechanical design
- Called this an “analog computer” for *analogy*
  - Later (1970’s)—*analog* became opposite of *digital*
Why Analog Computers (Analog Computer Simulation)?

- Cheaper, smaller, quicker
  - Eg: building a bridge
- Can explore effects of changing design parameters, or different input signals—also time scaling (faster or slower in model than in reality)
- Also used to model other types of systems—chemical, biological, …
- Special purpose “analog computers” developed
Computer Simulation using Software

- Like a video game
- Solve the differential equations numerically (approximately), rather than using an electric circuit
- Easier to do hard things with software
  - Logic, switches, relays
  - Random quantities
  - Parameter changes and optimization
Differential Equations

- What is a derivative?
- How do you represent it?
- How does it get into an equation?
- What does “solving” a differential equation mean?
  - Initial conditions, input, output
- With computer simulation, we don’t actually have to do any math!
- ..which is good because most models can’t be solved mathematically
Why Use Digital Components?

- Often Cheaper
- Usually Smaller/lighter
- Usually needs Less power
- Often more precise
- Can re-program
- Can use same components (with different programming)--generality
Some uses of Computer Simulation

• Weather forecasting (including hurricane tracking)
• Financial modelling (for investments, business decisions)
• Gaming (video games that simulate objects interacting)
Some uses of Computer Simulation

- Traffic prediction
- Physics (models and simulations of universe expansion, asteroid paths, etc)
- Training (e.g., flight simulators)
- Film (cgi; animated characters that move and interact, based upon mathematics), computer simulation and graphical output

- Here is one tie to Science Fiction