Theory of Computation, First Class

[www.cs.virginia.edu/~njb2b/theory](http://www.cs.virginia.edu/~njb2b/theory)

A tale of computers, math, problem solving, life, love, and tragic death- and also Alan Turing

Textbook: Introduction to the Theory of Computation, by Michael Sipser (MIT), 2nd Edition, 2006

How to Solve It, by George Polya, Princeton University Press, 1945 (supplemental reading)

* Problem solving

[www.cs.virginia.edu/~robins/CS\_readings.html](http://www.cs.virginia.edu/~robins/CS_readings.html)

Themes

* Nature of computation
  + What can and can’t be computed
  + What is a computer?
* Computing Machines
* Underlying Principles of Computation
  + Fundamental parts
* Applications of this Theory
* “Standing on the shoulders of giants”
  + Influenced and inspired to be better CS majors
* Problem Solving and Creativity
  + The mathematician’s apology
* Self-Discipline (very open ended)
  + Start things early, do things well

Midterm and Final will most likely be take-home or in-class

Homework = lots of problem solving, working in groups, and not formally graded, many of the exam questions will come from the homework

* Tons of problems on the problem sets (400+ problems)

Extra credit problems do exist: in-class and take home, finding mistakes in materials

Exam is the problem sets usually – do all of the problem sets, pass the exam

Final project = open-ended, lots of things that you can do for this (see the webpage)

Midterm and final = 35%/each

Project = 30%

Extra credit = up to 10%

Each day early that you turn in the project, get +1 extra for each day early

Project due the same day that the final is

Project extra credit will be appended to extra credit, not to the project itself

Nathan Brunelle

230 Rice Hall, [natebrunelle@gmail.com](mailto:natebrunelle@gmail.com)

Q&A blog posted on the class website

Weekly problem solving sessions: Mondays 7:30-8:30 pm, location TBA

Randy Pausch’s Time Management 2007 video is extra credit

WHAT IS A COMPUTER?

* Threads and mathematical properties
* Tinker toys are actually Turing complete
* Orbiting planetary systems are also complete
* Wim Klein = hired by CERN as their first supercomputer
  + Whose jobs are safe?
  + Jobs that disappear because of the computer, especially the “computer”

WHY SHOULD WE STUDY THEORY?

* The Carnot engine: model of any heat engine, independent of implementation, a cap on the efficiency of any engine (fundamental), regardless of materials, etc.
* Take something specific 🡪 abstract it to make it easier to think about 🡪 make claims about anything using that abstraction \_\_. Motivates further study and research

Spinning 5 test tubes simultaneously in a 12-hole centrifuge in a balanced way?

* Balanced = the net force on the axis of rotation is zero
* Everything at an equal angle to everything else
* Non-trivial rotational symmetry
* Summing zero and zero by the idea of superposition
* Linearity and superposition
* Complementarity

Problem 1 + 2 + 3 + 4 + … + 100 =?

= 5050 because 1+100 repeating until 50+51

Induction = must have the goal in advance, easy to make the mistakes in an inductive proof, must a priori know the formula/result, hard to understand, difficult to check

None of the problems in this class require induction.

1^3 + 2^3 + 3^3 + … + n^3 = ?

What is the value of i^i? (use Euler’s)

There are arbitrarily long strings of composite numbers between primes

Does exponentiation preserve irrationality?

A is irrational, d is irrational, a^d is irrational?

Are some infinities greater than other infinities?

Historical Perspectives:

* Euclid = founder of geometry
  + Father of modern mathematics
  + Founder of the axiomatic method
  + Combining theorems into other theorems
  + Make larger statements from smaller statements
* What is a platonic solid
  + A 3-d figure where all of the faces are a regular 2D figure
* Euclid’s Axioms
  + Any 2 points can be connected by exactly one straight line
  + Any segment can be indefinitely extended into a straight line
  + Center + radius = unique circle
  + All right angles are equal to one another
  + Given a line + point, there is exactly one line || that goes through the point (the parallel postulate)
  + Non-Euclidean geometries come from modification of the parallel postulate.
    - * Hyperbolic geometry = given a line and a point, there are an infinity of lines passing through that point that do not intersect the first line
      * Not all triangle have the same angle sum
      * There are no similar triangles
      * Used in relativity theory
    - Spherical/elliptic geometry: there are no parallel lines
      * Given a line and a point off of the line, there are no parallel lines passing through that point
      * Lines are great circles (geodesics)
      * Figures have a maximum size