Introduction
Why Take This Course?

• “Software” is an amazing idea
  ▪ One of the core drivers of computer science

• Software is not just something humans write
  ▪ Intended to be *read* and *manipulated* by a machine

• Design intention: Compilers
  ▪ Compiler = *translator* from one programming language into another
  ▪ Typically, source code to assembly code
    - Then, assembler translates into machine code

• But compiling code is not the only possibility…
Three Related Topics

- Program Analysis
  - Prove facts about programs’ behavior
  - Grew out of optimizing compilers
  - Most popular use today: static bug detection

- Program Verification
  - How to argue that a program is correct?
  - State of the art: machine checked proofs of correctness

- Program Synthesis
  - Writing code is hard!
    - Good for employment of software engineers, but maybe bad overall
  - Develop ways to *search* for code satisfying a specification
  - Key difference from machine learning: resulting program should *always* work, not just probabilistically
Prerequisites

- COMP 105 or graduate standing
  - Ideas we will use in this class:
    - Functional programming
    - Operational semantics
    - Type systems
    - Lambda calculus
  - Talk to me if you’re not sure
(Possible) Topics

- Lambda calculus and operational semantics review
- Dataflow analysis
- Abstract interpretation
- Symbolic execution
- SMT solvers
- Model checking and LTL
- Type inference and points-to analysis
- Axiomatic semantics and Hoare Logic
- Verification with Dafny
- Separation logic
- Proofs in Coq
- Inductive synthesis and programming by example
- Enumerative and stochastic search
- Constraint-based synthesis
Grading

• Programming projects (50%)
  ■ Equally weighted
  ■ Will cover major topics:
    - Tentative list: OCaml warmup; (constraint-based analysis?); dataflow analysis; symbolic execution; program verification; program synthesis
  ■ I reserve the right to add graded homework if needed

• Midterms (24%)

• Final (25%)
  ■ Take home exam

• Meet your professor (1%)
Textbook

• None

• There is simply no book available that covers the right set of topics
  - Use these lecture notes as a reference
  - Take your own notes
Other administrivia

• We will try to use gradescope
  - Use entry code to add yourself to the class
• OCaml version 4.07
• Announcements and discussions on Piazza
  - Do not post code or test cases on Piazza
  - Do not give away answers on Piazza
• Projects due at 11:59 on due date
• Homework (if any) due at start of class on due date
  - Unless otherwise specified
• Let me know as soon as possible if you have an excused absence
• Avoid academic dishonesty