CSCE 4430: Programming Languages - Fall 2018

Instructor: Paul Tarau, Professor - see my home page for contact info and office hours.

Graders:
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Midterm exam: TBD, open net

Final exam: TBD cumulative, open net

Description and Objectives:
A comprehensive programming language course, with emphasis on programming paradigms and language processors - and some of their formal models like Predicate Logic and Lambda Calculus. Hands-on work with implementations of key concepts (recursion, inheritance, unification, backtracking, type inference, infinite and lazy data objects, threads. The course also provides a glimpse at salient features of modern object oriented languages and an overview of language implementation techniques, run-time systems and memory management in an efficient procedural language.

Syllabus
Basics
- From Turing machines and Lambda calculus to today's programming languages
- Programming Paradigms: logic, functional, object oriented, imperative
- Language Processors: Interpreters and Virtual Machines, Compilers

Functional Programming (with Python and Haskell)
- Intro to Untyped Functional Programming with Python
- Finite functions: dictionaries, arrays, sets
- List and set comprehensions
- Coroutining with yield
- Programming with Recursive Functions and Lists
- Higher Order Functions
- Intro to Types and Functional Programming with Haskell
- Working with Fold, Map, Zip
- Polymorphism, Type inference
- Recursive Data Types and Pattern Matching in Haskell
- Lazy Evaluation, Computing with Infinite Lists
- Lambda Calculus, De Bruijn Indices
- Simply-typed Lambda Terms, Type Checking vs. Inference
Evaluation of Lambda Terms, Normalization

Logic Programming (with Prolog)
- Intro to Prolog: Facts and Rules, Recursion, Lists and Compound Terms, Arithmetic
- Propositional and Predicate logic
- Unification and Horn Clause Resolution in Prolog
- Non-determinism and Backtracking
- Case study: solving cryptarithmetic puzzles
- Definite Clause Grammars, Parsing and Generation
- Problem solving with Prolog
- Runtime Code Generation: the dynamic database
- Higher order Predicates and Meta-interpreters
- Generating Lambda Terms in Prolog
- Type inference for simply-typed Lambda Terms in Prolog

Object Oriented Programming (with Python and Java)
- Classes and Objects in Python 3
- Overview of Java 9
- Static vs. Dynamic Aspects
- Classes, Instances, Objects, Interfaces, Mix-ins
- Collections, Streams, Lambdas, Iterators and IO operations
- Reflection and Serialization

Low Level Imperative Programming (C)
- Basics: assignment, function calls, lexical scoping, memory representations, stack and heap
- Implementing dynamic memory management and garbage collection
- Implementing high-level programming languages in C

Concurrent Programming
- Event driven programming, Coroutining, Futures, Multi-threading
- Distributed Programming, Message Passing, Coordination

Future Trends in Programming Language Design

Prerequisites: Data Structures, Algorithms, Solid Coding Experience

Recommended books and online materials:
- Tucker & Noonan: Programming Languages, Principles and Paradigms, McGraw Hill
- The Art of Prolog by Sterling and Shapiro, MIT Press
- Doets & van Eijck: The Haskell Road to Logic, Math and Programming
- Harper's draft PL book
- Java for Students: Douglas Bell & Mike Parr, Prentice Hall
**Evaluation:**

- 2 Individual Exams: 30%+30%
- Individual Assignments: 40%

**Software, tutorials and related links:**

- Python 3 tutorial
- Functional Python 3 also, a good blog on it
- Python 3 generators and list-comprehensions
- Python 3 itertools library
- SWI Prolog
- A good prolog tutorial.
- Haskell compiler GHC
- Haskell tutorials. On Haskell Functors and Monads this and this. On IO and imperative constructs.
- Java interpreter/compiler JDK

**Outcomes:**

1. Understand foundational concepts of programming languages, with emphasis on programming paradigms and language processors.
2. Have a practical understanding of commonalities and differences between major programming paradigms.
3. Understand key object oriented, logic and functional programming concepts.
4. Understand key concepts of event driven and concurrent programming.
5. Understand the use and implementation of modern programming language concepts like recursion, inheritance, reflection, unification, backtracking, type inference, infinite data objects and threads.