

# Princeton University

## COS 217: Introduction to Programming Systems

### Fall 2014 Midterm Exam Preparation

## Topics

*You are responsible for all material covered in lectures, precepts, assignments, and required readings. This is a non-exhaustive list of topics that were covered:*

### 1. Number Systems

- The binary, octal, and hexadecimal number systems
- Finite representation of unsigned integers
  - Operations on unsigned integers
- Finite representation of signed integers
  - Signed magnitude, ones' complement, two's complement
  - Operations on signed integers
- Finite representation of rational numbers

### 2. C Programming

- The program preparation process: preprocess, compile, assemble, link
- Program structure: multi-file programs using header files
- Process memory layout: text, stack, heap, rodata, data, bss sections
- Data types
- Variable declarations and definitions
- Variable scope, linkage, and duration/extent
- Constants: #define, constant variables, enumerations
- Operators
- Statements
- Function declarations and definitions
- Pointers and arrays
  - Call-by-reference, arrays as parameters, strings
  - Command-line arguments
- Input/output facilities
- *Text files (see King Chapter 22)*
- Structures
- Dynamic memory management
  - malloc(), calloc(), realloc(), free()
  - Common errors: dereference of dangling pointer, memory leak, double free
- Abstract objects
- Abstract data types; opaque pointers
- Generic data structures and functions
  - Void pointers
  - Function pointers and function callbacks
- *Parameterized macros and their dangers (see King Section 14.3)*

### 3. Programming-in-the-Large

- Testing
  - External testing taxonomy: statement, path, boundary, stress
  - Internal testing techniques: validate parameters, check invariants, check function return values, change code temporarily, leave testing code intact
  - General testing strategies: automate the tests, test incrementally, let debugging drive testing (fault injection)

- Building
  - Separate independent paths before link
  - Motivation for make, make fundamentals, macros, abbreviations, pattern rules
- Program and programming style
  - Bottom-up design, top-down design, least-risk design
- Debugging
  - General heuristics for debugging: understand error messages, think before writing, look for familiar bugs, divide and conquer, add more internal tests, display output, use a debugger, focus on recent changes
  - Heuristics for debugging dynamic memory management: look for common DMM bugs, diagnose seg faults using gdb, manually inspect malloc(), calls, comment-out free() calls, use Meminfo, use Valgrind
- Data structures and algorithms
  - Linked lists
  - Hash tables: hashing algorithms, defensive copies, key ownership
- Modularity
  - History of modularity: non-modular, structured, abstract object, abstract data type programming
  - Module qualities: encapsulates data, is consistent, has a minimal interface, detects and handles/reports errors, establishes contracts, has strong cohesion, has weak coupling
- Performance Improvement
  - When to improve performance
  - Improving execution (time) efficiency: do timing studies, identify hot spots, use a better algorithm, enable compiler speed optimization, tune the code
  - Improving memory (space) efficiency: use a smaller data type, compute instead of storing, enable compiler space optimization

#### 4. Applications

- De-commenting
- Lexical analysis using finite state automata
- String manipulation
- Symbol tables, linked lists, hash tables
- Dynamically expanding arrays

#### 5. Tools: The Unix/GNU programming environment

- Unix/Linux, Bash, Emacs, GCC, GDB, Make, Gprof

## Readings

*As specified by the course "Schedule" web page...*

#### Required:

- *C Programming* (King): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20.1
- *Computer Systems* (Bryant & O'Hallaron): 1

#### Recommended:

- *Computer Systems* (Bryant & O'Hallaron): 2
- *The Practice of Programming* (Kernighan & Pike): 1, 2, 4, 5, 6, 7, 8
- *Unix Tutorial for Beginners* (website)
- *GNU Emacs Tutorial* (website)
- *GNU GDB Tutorial* (website)
- *GNU Make Tutorial* (website)
- *GNU Gprof Tutorial* (website)

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