ECE 120 Midterm 1

HKN Review Session

Exam Time: Tuesday, February 14 (7:00-8:30pm)

Logistics

Exam: Tuesday, February 14, 7pm-8:30pm

Conflict exam: 5pm-6:30pm

Location: Check Compass for room assignment

UA Review Session: Sunday, February 12, 2pm-4pm

Overview of Review Session

- Abstraction
- Binary Types & Hexadecimal & Overflow
- Floating Point
- Boolean Operators
- C Programming
- FALL 2015 EXAM QUESTIONS

Abstraction/Levels of Transformation

- Abstraction - the means to simplify events **without going into heavy specifics**, reducing information to the essentials -> **productivity enhancer**
- Levels of Transformation (itself an example of abstraction !)
  - Problem Statement
  - Algorithm
  - Program (C)
  - Instruction Set Architecture (MIPS, LC-3 assembly language)
  - Microarchitecture (combinational/sequential logic circuits)
  - Logic gates (NOT AND OR)
  - Devices (CMOS)

Binary Types

- **Unsigned**
  1. Can only represent **nonnegative** integers
  - K = number of bits
  - Total unique representations → 2^k
  - Range → 0 to (2^k-1) e.g. $(10011)_2 \rightarrow (16+2+1) = 19_{10}$

  Decimal - Binary conversion: represent both as a sum of 2's powerful numbers.

- **Signed - Magnitude (rarely used)**
  1. First bit determines if positive or negative → 1 = negative, 0 = positive
  - Rest of bits determine magnitude
  - Range → --($2^{(k-1)}$-1) to ($2^{(k-1)}$-1) e.g. $(10011)_2 \rightarrow (-1) \times (2+1) = -3_{10}$

Binary Types *

- **2's complement**
  - ○ Positive numbers lead with "0", negative numbers lead with "1"
    - ○ *K* bits → can represent 2^k total numbers, half being positive and half being negative
  - ○ Can represent positive numbers from range --($2^{(k-1)}$) to ($2^{(k-1)}$-1)
  - ○ **Positive** numbers have the **same representation as unsigned types (with the MSB being zero)**; for **negative** numbers, do the following two steps to find their 2's complement representations from unsigned representations: e.g. $(-37)_{10}$
    - **Find the corresponding positive 2's complement value first (sign bit!)**
    - **FLIP ALL BITS & ADD 1**

Positional Weighting method (IN HW2!): quick way from 2's complement to decimal!

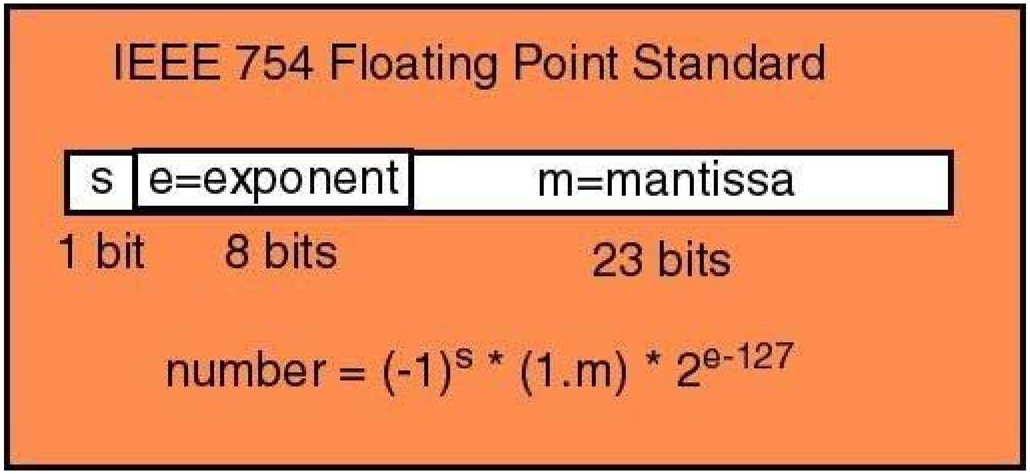
- the kth bit of the number has the "weight" of $2^{(k-1)}$
- except for the leftmost bit (MSB) which has the "weight" of $-2^{(k-1)}$

Overflow in Operations

- 2 primary operations: addition and subtraction (essentially +)
- **Checking for Overflow**
  - Unsigned operations
    - There is a nonzero carry bit (bit carries out of bit range)
  - 2's Complement operations
    - Result has wrong sign if
      - 2 positive numbers sum to negative number
      - 2 negative numbers sum to positive number
      - NOTE: **in 2's complement, a positive and negative number added never results in overflow**
    - Quick Check- For MSB, does carry in bit = carry out bit (i.e. $C_n = C_{n-1}$)?
      - If not, overflow has occurred

Floating Point

- Use IEEE 754 standard (32 total bits)
  - 1 sign bit
  - 8 exponent bits ○ 23 mantissa bits
- Increased precision
  => decreased range
- Conversion from floating point to decimal
- Conversion from decimal to floating point



Floating Point (cont.)

- Special Cases
  - **Denormalized representation** ■
    Exponent = 0
    - Mantissa takes any value
    - Formula: $(-1)^s * 0.\text{Mantissa} * 2^{-126}$
  - Exponent is all 1s
    - Mantissa = 0
- **$(-1)^s$ * infinity**
    - Mantissa not equal to 0
- **NaN**

Exponent	Mantissa (Fraction)	Interpretation
$1 \le$ exponent ≤ 254 (Normalized)	All values	$(-1)^{\text{sign}} \times (1.\text{mantissa}) \times 2^{\text{exponent}-127}$
exponent = 0 (Denormalized)	All values	$(-1)^{\text{sign}} \times (0.\text{mantissa}) \times 2^{-126}$
exponent = 255 (Overflow)	0	$(-1)^{\text{sign}}\infty$
	Non-zero	NaN (Not a Number)

Boolean Operators *

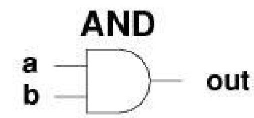
- NOT
- AND, NAND -

AND allows masking of bits

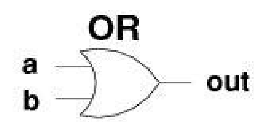
Mask: 00001111 **Value: 01011100**

Result: 00001100

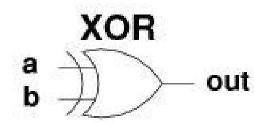
- XOR, XNOR
  1 A XOR B = A (NOT B) + (NOT A) B
- OR, NOR
- Note:
  1 Order of precedence:
    - (), NOT, AND, OR
      - AND, NOT, and OR are **logically complete**



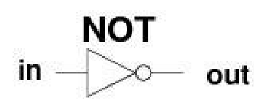
a	b	out
0	0	0
0	1	0
1	0	0
1	1	1



a	b	out
0	0	0
0	1	1
1	0	1
1	1	1



a	b	out
0	0	0
0	1	1
1	0	1
1	1	0



in	out
0	1
1	0

Hexadecimal *

- Base 16, Uses 0-9 and A-F
- Takes groups of 4 bits and represents them as symbols
    1. Ex: 0011 1101 0110 1110 → 3 D 6 E
- To go from hex to binary, write out each hex value into 4 bit binary
    1. Ex: 4E7F → 0100 1110 0111 1111
- Shortens binary representation by a factor of 4

Binary	Hex	Decimal
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7
1000	8	8
1001	9	9
1010	A	10
1011	B	11
1100	C	12
1101	D	13
1110	E	14
1111	F	15

Octal Notation:

Base 8, Uses 0-7

Takes groups of 3 bits and represents them as numbers from 0-7

C Programming

- Basic Characteristics
    1. High level/independent (of ISA), procedural, expressive

```c
#include <stdio.h>
#define pi = 3.1415926

int main() {

    int r = 10;

    float area;

    area = pi * r * r;

    return 0;

}
```

- Variables in C
    - Int, double, float, char
        1. Note that result is truncated during integer division!

```
int r = 10;
```

type name value

- Operators
  1. **Order of precedence: *, /, % and then +, -**
  - **Assignment operator: =**
  - **Relational : ==, !=, >, <, >=, <=**
  - **Bitwise: &, |, ~, ^ (AND, OR, NOT, XOR)**
  - **Logical: &&, ||**

- Basic I/O

```c
int a = 1;

float b = 0.1;

printf("a=%d, b=%f\n", a, b);
```

- Conditional Constructs

```c
int a = 5;
if (a < 10) {
    printf("a is less than 10\n")
}
```

$$\Downarrow$$

$a<10 \Leftarrow$

```c
int a = 5;
int b = 8;
if (a < 10) {
    printf("a < 10\n");
} else if (b < 10) {
    printf("b < 10\n");
} else {
    printf("b >= 10");
}
```

- Iterative Constructs

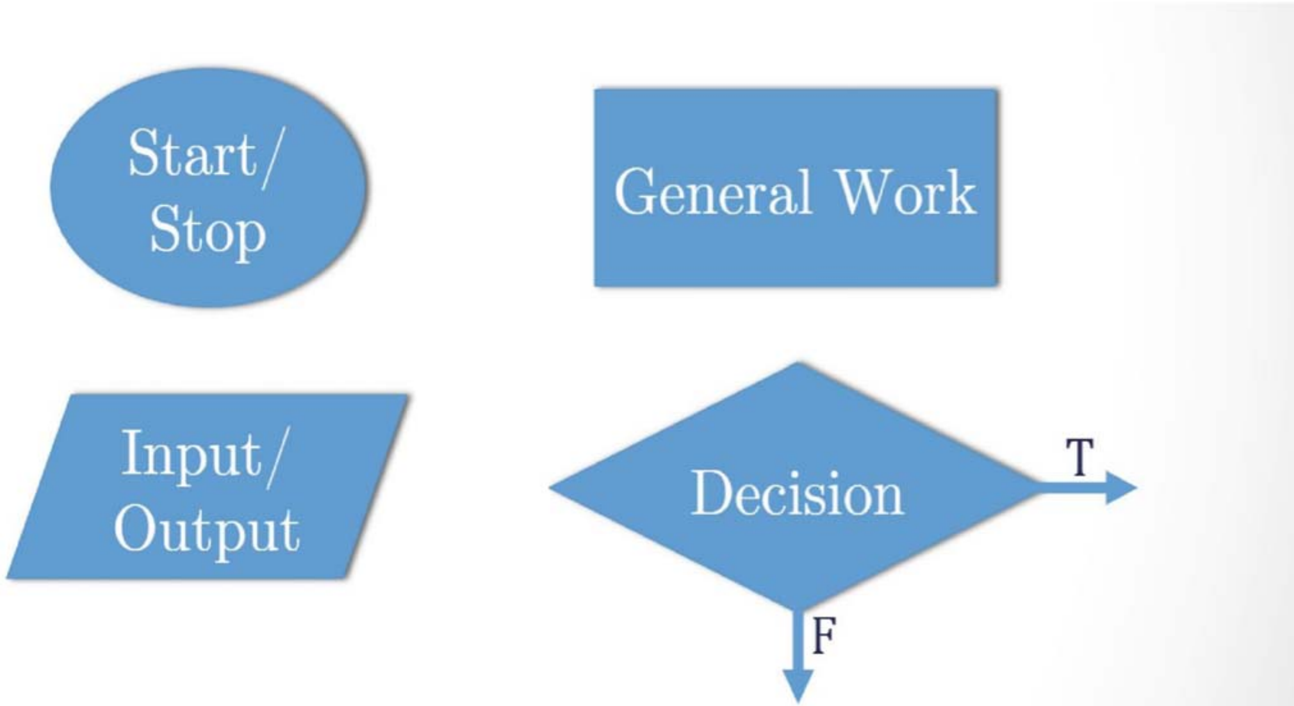
```
int i = 0;  A
while (i < n) {
  B /* Do something. */
    i ++;
}
```

Note: do-while loop will be able to get into the loop for at least once

```
int i;   A       B       C
for (i = 0; i < n; i ++) {
   D/* Do something. */
}
```

```
int i = 0;
do {
  B /* Do something. */
    i ++;
} while (i < n);A
```

Flow Chart Components



Cheat Sheet: Recommendations

- Common powers of 2
- 2's Complement
  1. Procedure of converting between decimal & binary types

     Representable range with K bits
- Floating Point
  1. Formula for general case ○ Special cases
- Overflow Conditions (both unsigned and 2's complement)
- Harder boolean operators
  1. XNOR, XOR, NAND, NOR
- Basic C syntax

General Advice

- Use your Cheat Sheet! ○ Don't memorize
- Read the directions carefully!!!!
- Don't be afraid to ask questions
- Relax and trust what you've learned :)