UNCA CSCI 235
Final Exam Spring 2018
May 8, 2018 3:00 pm – 5:30 pm

This is a closed book and closed notes exam. Communication with anyone other than the instructor is not allowed during the exam. **Furthermore, calculators, cell phones, and any other electronic or communication devices may not be used during this exam.** Anyone needing a break during the exam must leave their exam with the instructor. Cell phones or computers may not be used during breaks.

This exam must be turned in before 5:30 PM.

Name:___________________________________

Problem 1: C expressions (10 points)
In the left column, there are twenty tricky and not-so tricky C expressions. Write their values in the right column. Express your answers in simple base 10 expressions, such as 235 or -235. You may assume that all of these numbers are stored in 16-bit two's complement representation, the usual `short`.

`022`	18
`0x22`	34
`22 >> 3`	2
`22 << 3`	176
`22 / 3 * 5`	35
`22 * 3 / 5`	13
`22 & 7`	6
`22 && 7`	1
`22 | 7`	23
`22 || 7`	1
`22 ^ 7`	17
`22 > 7`	1
`~22`	-23
`!22`	0
`22*0 && 10000/235`	0

Problem 2: Range (2 points)
What is the range of values that can be stored in an 8-bit twos-complement numbers? (By the way, the `byte` of Java is an 8-bit twos-complement number.)

-128 to 127

Problem 3: Decimal to two's complement conversion (4 points)
Convert the following four signed decimal numbers into **six**-bit *two's complement* representation. Some of these numbers may be outside the range of representation for **six**-bit two's complement numbers. Write "out-of-range" for those cases.

-10	**-1**
10	**40**

Problem 4: Q4.4 to decimal conversion (4 points)
Convert the following four Q4.4 *two's complement* numbers (four fixed and four fractional bits) into signed decimal representation.

00010001 **1 + 1/16** **1.0625**	**10001000** **-8 + 0.5** **-7.5**
11111111 **-1 + 15/16** **-0.0625**	**01000000** **4**

Problem 5: Decimal to Q4.4 conversion (4 points)
Convert the following three signed decimal numbers into Q4.4 *two's complement* numbers (four fixed and four fractional bits). If you can't express the number exactly, give the nearest Q4.4 representation.

-1.25	**11101100 (-2 + 0.75)**
0.2	**00000011 (3/16 or 0.1875)**
2.5	**00101000**

Problem 6: Floating point arithmetic (2 points)
I've tried both of these following C floating-point multiplications in gdb and one results in 1.0 and one does not:

```
    5 * 0.2
    2 * 0.5
```

Which is 1.0? Give an explanation for your choice.

2 * 0.5 will be 1.0, because 0.5 is a power of 2. It can be represented exactly. 0.2 will be approximated.

Problem 7: Adding numbers with flags (8 points)
Add the following pairs of six-bit numbers. Based on the result of this addition, set the four x86-64 status bits: CF (carry), OF (overflow), SF (sign) and ZF (zero).

010010 + 010010 100100 CF_0, OF_1, SF_1, ZF_0	110000 + 010000 000000 CF_1, OF_0, SF_0, ZF_1
011111 + 110000 001111 CF_1, OF_0, SF_0, ZF_0	111000 + 110000 101000 CF_1, OF_0, SF_1i, ZF_0

Problem 8: CSCI arithmetic (4 points)
Perform the following operations and express the results as they should be for CSCI 235 and other geeky environments.

16 ki * 32	512 ki
2 Mi / 8	256 ki
$\log_2$(64 ki)	16

Problem 9: Expected time (2 points)
Assume that 80% of the time a requested memory access is found in the cache and retrieved in 20 n sec; and that the other 20% of the time, 40 µ sec is required. What is the average time required to perform a read request?

0.8 * 20 nsec + 0.2 * 40 µsec = 0.8 * 0.020 µsec + 0.2 * 40 µsec
0.016 µsec + 8 µsec = 8.016 µsec

Problem 10: goto programming (8 points)
In the style of a recent homework, implement the C function shown below using only two control structures:

```
    goto label ;
    if (expression) goto label ;
```

This specifically means that you can't use the `for`, `while`, `switch`, `break`, `continue`, or even the statement block delimiters { and }. You can use the `if`, but only when the conditional expression is immediately followed by a `goto` statement. Also, do not use the `?:` operator of C (and Java) to simulate an `if-then-else`.

```
  int huh(int p, int *d) {
      if (p > 0) {
        ++*d ;
      }
      return p + *d ;
  }
```

Write your solution in the space below…

```
int huh(int p, int *d) {
     if (p <= 0) goto skipIt ;
     ++*d ;
skipIt:
     return p + *d ;
}
```

Problem 11: Command line arguments (4 points)
This is very tricky! Suppose you have written the following program and compiled and linked it into an executable called `evilProg`.

```
#include <stdio.h>
int main(int argc, char *argv[]) {
  printf("%s %d %s%s\n",
          argv[1], argc-2, *(argv+2), argv[3]) ;
  return 0 ;
}
```

What command line arguments do you pass to `evilProg` to make it print this single output line?

won too 3 for

There is more than one correct answer.

```
./evilProg      "won two"    f     or    x
```

Problem 12: C Programming (16 points)
Write a program that reads (**using `scanf`**) a sequence of time-of-day value from a terminated standard input stream. The times are entered in “traditional” US time-of-day format as shown below.

```
        12:10:00 AM     7:10:03 AM
               12:05:10 PM    5:30:00 PM
```

Your output should be a neatly formatted list of ISO 8601 standard 24-hour clock times followed by a count of the number of clock times in the input stream. So, for the above example, the output should be:

```
    00:10:00
    07:10:03
    12:05:10
    17:30:00
Time read:    4
```

You may assume that the input contains properly formatted US time-of-day values but that white spaces (spaces, tabs, or new lines) can occur before and after the numbers and the AM and PM tokens. (This actually makes the programming task with `scanf` a little easier.)

Assume that 12:00:00 AM is midnight (00:00:00) and 12:00:00 PM is noon (12:00:00). That’s what the US Government Printing Office decided in 2008. Also, it’s the easiest to program.

Write your answer in the space below

```
// Your answer goes here.
#include <stdio.h>
int main(int argc, char *argv[]) {
    int timeCount = 0 ;
    int usHour, minute, second ;
    int isoHour ;
    char halfDay[3] ;
    while (scanf("%d:%d:%d %2s",
                 &usHour, &minute, &second,
                 halfDay) == 4) {
      timeCount++ ;
      // Before or after noon?
      if (halfDay[0] == 'A') {
        isoHour = 0 ;
      } else {
        isoHour = 12 ;
      }
      // Have to handle 12 differently...
      if (usHour != 12) {
        isoHour = isoHour + usHour ;
      }
      printf("    %02d:%02d:%02d\n",
             isoHour, minute, second) ;
    }
    printf("Time read: %8d\n", timeCount) ;
}
```

Problem 13: Expression to truth table and circuit (8 points)

First, fill in the truth table on the right below so that it corresponds to the following Java (or C or C++) assignment:

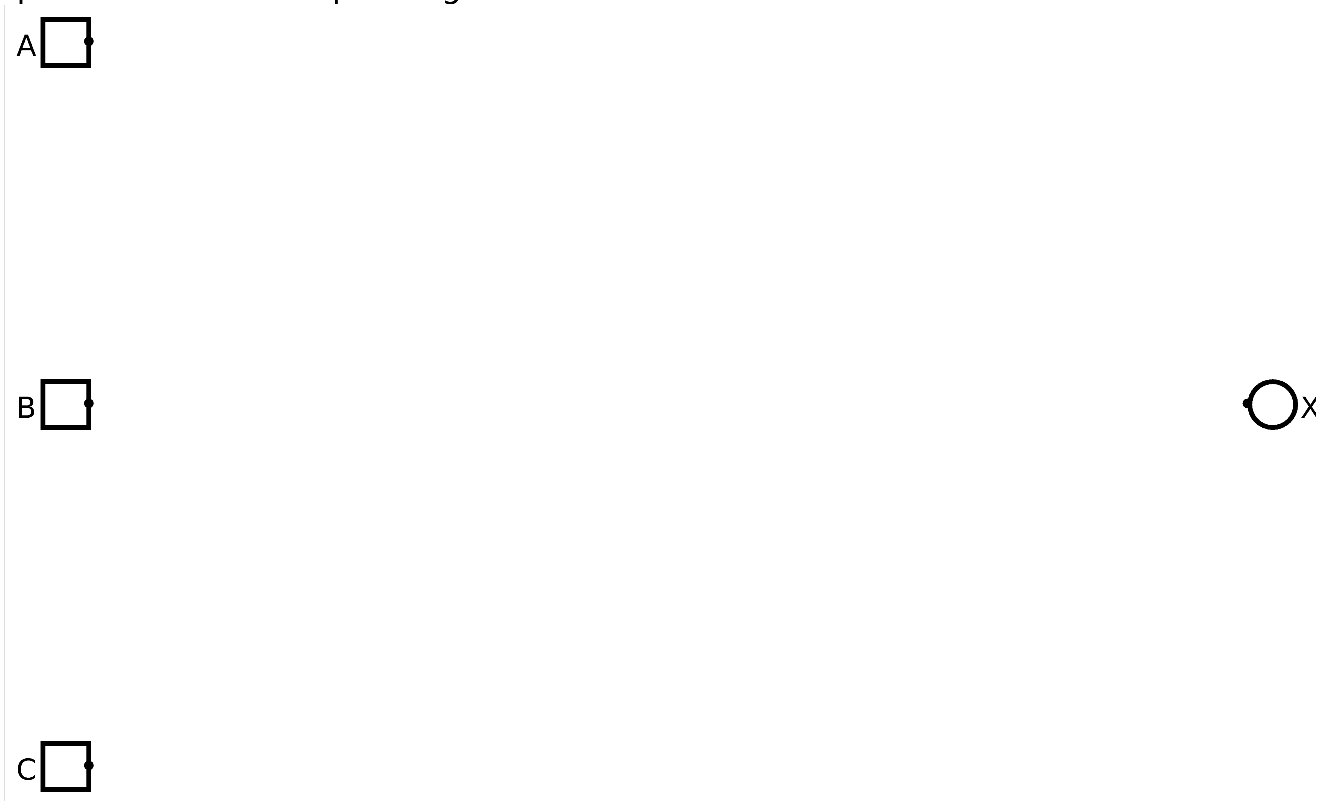
```
X = (A || !B) && C
```

If you prefer the computer engineering style, you can think of the equation as

```
X = (A + B’) C
```

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Second, draw a logic circuit (AND, OR, …) to implement the boolean expression and corresponding truth table.



Problem 14: Truth table to expression and circuit (8 points)

The truth table below specifies a Boolean function with three inputs, **A**, **B**, and **C** and one output **X**.

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

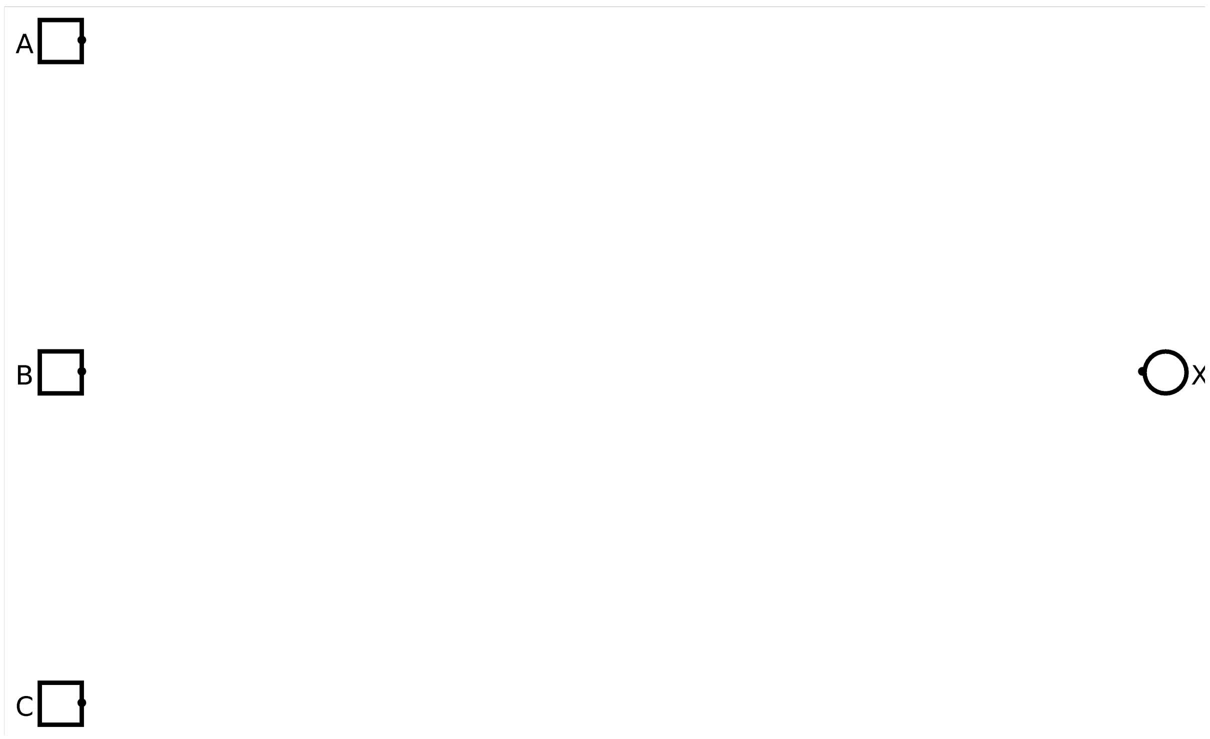
First, write a Boolean expression corresponding to the function specified in the table. (You do not need to write an "efficient" expression.)

```
!A && !B && C || !A && B && !C || A && !B && !C || A && !B && C
```

or

```
!B && C || !A && B && !C || A && !B
```

Second, draw a logic circuit (AND, OR, ...) to implement the boolean expression and corresponding truth table.



Problem 15: Pointers (8 points)
In this question, you are to fill in boxes representing the following C integer or pointer variables to show their values after each of seven sections of C code are executed. **You should consider all the sections as being independently executed after the following declaration and initialization statements**:

```
int    V[3] = {181, 202, 255} ;
int    *p = NULL ;
int    *q = NULL ;
```

As you might guess, **`null`** in Java is similar to **`NULL`** in C. Draw the value **`NULL`** with a little ***X***. Don't ever just leave the pointer variable boxes empty.

```
p = V ;
q = V+1 ;
*p = 200 ;
*q = 300 ;
```

p	&V[0]	V[0]	200
		V[1]	300
q	&V[1]	V[2]	255

```
q = &V[1] ;
p = q++ ;
*p = *q ;
```

p	&V[1]	V[0]	181
		V[1]	255
q	&V[2]	V[2]	255

```
p = &V[0] ;
q = &V[2] ;
*p = *q – *p ;
*q = q - p ;
```

p	&V[0]	V[0]	74
		V[1]	202
q	&V[2]	V[2]	2

```
p = &V[0] ;
*(p++) = 235 ;
(*p) = 300 ;
```

p	&V[1]	V[0]	235
		V[1]	300
q	*X*	V[2]	255

Problem 16: Definitions (10 points)
To finish off, give short definitions of the following concepts, functions, hacks, types, variables, etc., as you have seen in this course (including its labs). *Feel free to skip two: I will grade the best six of eight definitions.*

`digitalWrite()`
x86-i64
Virtual memory
stack
`digitalRead()`
Randal E. Bryant
Raspberry Pi
current limiting resistor