# *Comp 150 Final Exam Overview.* *Exam Time: Tuesday, May 1, 9-11AM*

## Resources During the Exam

The final exam (250 points) will be closed book, no calculators or computers. You may bring notes on **four** sides of 8.5x11 inch paper (either both sides of two sheets, or four sheets written on single sides). Write this as you study! I mostly want to test you on concepts, not memorized rote facts. The Pip machine/assembler code table will be supplied, so you don't need to write it out (see http://hwheeler01.github.io/comp150/PipCode.pdf).

**Main topics that may be on the final exam: Previous exam topics + Class Notes.**

1. Previous exam topics, see the reviews for exams 1 and 2.
2. Conversions between different number systems (binary, decimal and hexadecimal).
3. Read/write Pip assembler and play computer. Understand the use of the accumulator and symbolic variables and labels for jumps. Follow and write short computational sequences and if-else or while-loop logic with Pip assembler code.
4. Convert any way between Boolean expressions, sequential logic circuits, and truth tables.

**Exam emphases**

1. About 45% of the exam will be on new topics since exam 2 (See items 2-4, above).
2. Problems from later in the semester generally include skills needed from early in the semester implicitly. A non-exhaustive list of things you should know how to read and write in Python: functions, for loops, while loops, nested loops, conditional statements, print statements, lists, dictionaries, strings, integers, floats.
3. The best characterization of the course is the course itself, so reviewing your homework is a good review.
4. Note: Nothing from the plotting unit (ggplot, pandas) will be on the final exam.

**Read the following before looking at either the problems or the solutions!**

1. Study first and then look at the sample problems. The sample problems cannot give complete coverage, and if you look at them first, you are likely to study just these points first, and will not get an idea how well you are prepared in general. Look at the list at the top of the page and start by filling in any holes.
2. Do not look at the answers until you have fully studied and tried the problems and gotten *help* getting over rough spots in the problems if you need it! Looking at the answers before this time makes the problems be just a few more displayed examples, rather than an opportunity to actively learn by doing and seeing where you are. The *doing* is likely to help you be able to *do* again on a test.

*New sample problems start on the next page.*

**Review Problems for the Final Exam** (Solutions follow the problems.)

1. Write a sequence of PIP Assembler or machine code instructions that will copy the value of memory location 130 into memory location 131. (You do not need to write a whole program -- no HLT required.)
2. Convert the PIP machine code to assembler
   00001100 00010010
   00001111 00000000
   00010011 00000100
3. Convert the PIP Assembler to Machine code
   JMZ 12
   MUL #5
   NOT
4. Play computer with the silly program below, completing the log at the right, showing the machine state after each instruction.

```
IP-->  ACCUM   X  Y
-------------------
-- 0       0   0  0
0  2      -5   0  0
```

```
Address    Assembler code
0          LOD #-5
2          STO X
4          MUL #-1
8          STO Y
8          CPL X
10         JMZ L1
12         LOD X
14         ADD Y
16         JMZ L2
18     L1: LOD X
20     L2: ADD X
22         JMP L3
24         SUB #1
26     L3: HLT
```

5. a. Convert the following code to Pip Assembler.

```
if X == 0:
  Y = 3
else:
  X = Y
Z = X + Y
```

   b. What change would you need if the first line of pseudocode was

   `if X == Z:`

   Hint: What is a useful equivalent test?

6. Draw a circuit diagram that corresponds to the following Boolean expression: A(B + (CA)')

A -

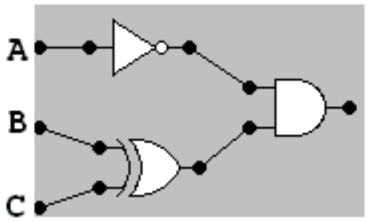
B -

C -

7. Complete the truth table below:

| A | B | A' | A'B | A+B | A'B ⊕ (A+B) |
|---|---|---|---|---|---|
| 0 | 0 | | | | |
| 0 | 1 | | | | |
| 1 | 0 | | | | |
| 1 | 1 | | | | |

8. Write a Boolean expression involving A, B, and C that corresponds to the following circuit:



9. Given the truth table below, write a Boolean expression in terms of A, B, and C for X.

| A | B | C | X |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |

10. Complete the truth table if X is true whenever B is different from both A and C

| A | B | C | X |
|---|---|---|---|
| 0 | 0 | 0 | |
| 0 | 0 | 1 | |
| 0 | 1 | 0 | |
| 0 | 1 | 1 | |
| 1 | 0 | 0 | |
| 1 | 0 | 1 | |
| 1 | 1 | 0 | |
| 1 | 1 | 1 | |

11. What is printed? Be careful to follow the order of execution, not the order of the text!

```
def foo(x):                 #1
    return x*2              #2

def bar(a, n):              #3
    print(foo(n+1))         #4
    print(foo(a))           #5

print('go')                 #6
bar('now', 4)               #7
```

12. Do the following base conversions. Show work.
   a. Convert the decimal number 54 into binary.
   b. Convert the binary number 1111001101100100010 into hexadecimal, without converting the entire base 2 representation to base 10 first.

13. Do the following base conversions. Show work.
   a. Convert the hexadecimal 2AF to decimal.
   b. Convert the decimal 424 to hexadecimal.

14. Add the following binary numbers. Hint: Work place by place; add and each 2 makes a carry. Show work

```
    101011
  + 100110
```

15. What is printed? Hint: The list `nums` is modified while it is being referred to as `newVals` in `foobar`.

```
def foobar(oldVals, newVals):   #1
    for i in oldVals:           #2
    newVals.append(i+1)         #3

nums = [6]                      #4
foobar([1, 3, 8], nums)         #5
print(nums)                     #6
```

16. What is printed?

```
def f(x):
    return 2*x + 1

print(f(1), f(f(1)))
```

17. What is printed?
```
   x = 16                 #1
   while x > 2:           #2
     x = x/2              #3
     if x > 3 and x < 7: #4
       print(3*x)         #5
     else:
       print(x)           #6
```

18. What is printed? Be careful of the order of completion of the nested loops!
```
for s in ['abc', 'de', 'f']:   #1
  for ch in s:                 #2
    print(ch*2, end=' ')       #3
  print()                      #4
```

19. Write a function `upper2` that takes a single string as parameter and *prints* the string twice on a line in upper case.
```
def upper2(s):
```

20. Write a function that takes a single string as parameter and *returns* the string repeated twice in upper case.
```
def upper2ret(s):
```

21. Redefine the function `upper2` so it *uses* the function upper2ret.
```
def upper2(s):
```

22. Write a function `printListUpper` that has a parameter `words`, which is a list of strings, and prints each in upper case on the same line. If `words` were `['hi', 'there']` then the following would be printed:
```
HI THERE
```
```
def printListUpper(words):
```

23. Write a function `printShortUp` that has a parameter which is a list of strings, and *prints* each string *that is shorter than the numeric parameter* `n` in upper case on the same line. If words were `['hi', 'there', 'you']` and `n` were 4, then the following would be printed:
```
HI YOU
```

```
def printShortUp (words, n):
```

24. Write a function `newListUpper` that has a parameter which is a list of strings and creates and *returns* a new list containing each string in upper case. If words were `['hi', 'there']` then `['HI', 'THERE']` would be returned.
```
def newListUpper(words):
```

***Answers on the next page***

**Final Exam Review Problem Answers**

1. LOD 130
   STO 131

2. JMP 18 ; 0000 no #; JMP code 1100; 18 = 16+2 in binary 00010010
   HLT ; 0000 no #; HLT code is 1111; second byte just 0
   DIV #4 ; pound sign from 0001; DIV code 0011; 4 from binary 00000100

3. 00001101 00001100 ; no #; JMZ; 12 = 8+4
   00010010 00000101 ; # ; MUL; 5 = 4+1
   00001001 00000000 ; no #; NOT; just 0

```
4.
IP--> ACCUM  X Y
----------------
--  0     0  0 0
 0  2    -5  0 0 LOD #-5;acc=-5
 2  4    -5 -5 0 STO X ;X=acc=-5
 4  6     5 -5 0 MUL #-1 ;acc=-5*-1=5
 6  8     5 -5 5 STO Y ;Y=acc=5
 8 10     1 -5 5 CPL X ;-5<0 true acc=1
10 12     1 -5 5 JMZ L1; acc!=0;no jump
12 14    -5 -5 5 LOD X ; acc=X=-5
14 16     0 -5 5 ADD Y ;acc=acc+Y=-5+5=0
16 20     0 -5 5 JMZ L2 ;acc is 0; jump
20 22    -5 -5 5 ADD X ; acc=acc+X=0+-5
22 26    -5 -5 5 JMP L3 must jump
26 --    -5 -5 5 HLT
```

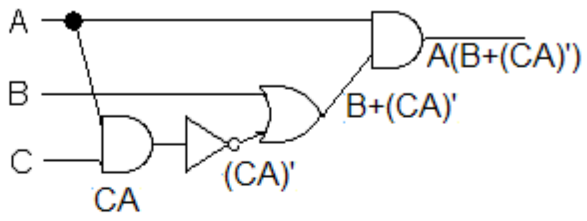
5a.

```
       LOD X   ; acc = X
       NOT     ; if acc != 0 (X != 0) acc now 0 (false)
       JMZ ELSE  ; jump if acc is 0 (X != 0)
       LOD #3  STO Y
       JMP PAST
ELSE:  LOD Y
       STO X
PAST:  LOD X
       ADD Y
       STO Z
```

b. if X==Z:
is the same as
  if X-Z == 0:
so just insert the second line to calculate X-Z
(and I revised the comment on the next line for NOT):

```
       LOD X   ; acc = X
       SUB Z   ; inserted line!   acc = X - Z
       NOT     ; if acc != 0 (X-Z != 0; X != Z) acc now 0
       ...
```

6. (Could use NAND instead of AND and NOT)



7.

| A | B | A' | A'B | A+B | A'B ⊕ (A+B) |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 1 |

8. A'(B ⊕ C)

9. A'B'C' + A'BC + ABC

10.

| A | B | C | X |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

11.
```
go
10
nownow
```

```
line comment
6    print go  (earlier lines only definitions)
7    Call bar
3    a is 'now' and n is 4
4    n+1 is 4+1 is 5; call foo(5)
1    x is 5
2    return 2*5 is 10
4    print returned 10
5    call foo
1    x is 'now'
2    return 'now'*2 is 'nownow'
5    print returned nownow
```

12a. 110110: 54/2 = 27 R 0, 27/2 = 13 R 1, 13/2 = 6 R 1, 6/2 = 3 R 0, 3/2 = 1 R 1, 1/2 = 0 R 1
remainders backwards: 110110
b. 3CD92 11 1100 1101 1001 0010 group from the right!
3 C D 9 2

13a $2*16^2 + 10*16 + 15 = 512 + 160 + 15 = 687$
b. 424/16 = 26 R 8; 26/16 = 1 R 10; 1/16 = 0 R 1 Read remainders from right: 1 10 8; convert to hexadecimal digits: 1A8.

(If you do not like arithmetic with 16's, you could do binary conversions in the middle: part a: convert to binary, then decimal. Part b: convert to binary; then hexadecimal, but that is longer to do.)

14.
```
  1 111    carries
   101011
 + 100110
  1010001
```

15. `[6, 2, 4, 9]`
Execution starts at line 4 -- after the definitions
step by step – does not show the spaces and newlines, not a complete substitute for the final answer!

| Line | nums | i | comment |
|---|---|---|---|
| 4 | [6] | | |
| 5 | | | call foobar |
| 1 | | | oldVals is [1, 3, 8] and newVals is an alias for nums |
| 2 | | 1 | i is first element of oldVals |
| 3 | [6, 2] | | i+1 is 1+1 is 2, append to newVals (nums) |
| 2 | | 3 | i is next element of oldVals |
| 3 | [6, 2, 4] | | i+1 is 3+1 is 4, append to newVals (nums) |
| 2 | | 8 | i is next amd last element of oldVals |
| 3 | [6, 2, 4, 9] | | i+1 is 8+1 is 9, append to newVals (nums) |
| 2 | | - | done with sequence and done with loop |
| 6 | | | print [6, 2, 4, 9] (with square braces and commas) |

16. `3 7`

# f(1) is 2*1+1 = 3; f(f(1)) is f(3) = 2*3+1=7

17.

```
8
12
2
```

| line | x | comment |
|---|---|---|
| 1 | 16 | |
| 2 | | 16 >2 is True |
| 3 | 8 | 16/2 is 8 |
| 4 | | 8>3 and 8 < 7 is true and false is false |
| 6 | | print 8 |
| 2 | | 8 >2 is True |
| 3 | 4 | 8/2 is 4 |
| 4 | | 4>3 and 4 < 7 is true and true is true |
| 5 | | 4*3 is 12 -- printed |
| 2 | | 4 >2 is True |
| 3 | 2 | 4/2 is 2 |
| 4 | | 2>3 and 2 < 7 is false and true is false |
| 6 | | print 2 |
| 2 | | 2>2 false: skip loop |

18.

```
aa bb cc
dd ee
ff
```

| line | s | ch | comment |
|---|---|---|---|
| 1 | abc | | first in list |
| 2 | | a | first in character sequence 'abc' |
| 3 | | | print aa (but stay on same line) |
| 2 | | b | next in character sequence 'abc' |
| 3 | | | print bb (but stay on same line) |
| 2 | | c | last in character sequence 'abc' |
| 3 | | | print cc (but stay on same line) |
| 2 | | - | done with character sequence 'abc' |
| 4 | | | on to new line, done with inner loop |
| 1 | de | | next in list for outer loop |
| 2 | | d | first in character sequence 'de' |
| 3 | | | print dd (but stay on same line) |
| 2 | | e | next and last in character sequence 'abc' |
| 3 | | | print ee (but stay on same line) |
| 2 | | - | done with character sequence 'de' |
| 4 | | | on to new line, done with inner loop |
| 1 | f | | next in list for outer loop |
| 2 | | f | first in character sequence 'f' |
| 3 | | | print ff (but stay on same line) |
| 2 | | - | done with character sequence 'f' |
| 4 | | | on to new line, done with inner loop |
| 1 | | | done with list and outer loop |

19.
```
def upper2(s):
    print(s.upper()*2)
```

20.
```
def upper2ret(s):
    return s.upper()*2
```

21.
```
def upper2(s):
    print(upper2ret(s))
```

22.
```
def printListUpper(words):
    for s in words:
        print(s.upper(), end=' ')
```

23.
```
def printShortUp(words, n):
    for s in words:
        if len(s) < n:
            print(s.upper(), end=' ')
```

24.
```
def newListUpper(words):
    up = []
    for s in words:
        up.append(s.upper())
    return up
```