Comp 150 Final Exam Overview.

Resources During the Exam
You may use 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. Opcode table supplied showing both Assembler mnemonics and binary opcodes.

Main topics that may be on the final exam: Previous exam topics on Python + a bit on client/server programming, web notes on binary arithmetic, Pip assembler, gates/circuits/truth tables, and SQL.

1. Previous exam topics on Python
2. Formatting with local variables: format parameter **locals()
3. Limited topics from cgi scripting: no HTML, but I could show you the output of my dumpcgi.cgi script from some web page form, as an indication of what is produced by a form, and show you an alternate cgi script to receive the information, and ask you what the script prints.
4. Converting between binary and decimal (both directions!) converting between binary and hexadecimal (the easy way, both directions)
5. Read/write Pip assembler and play computer, using all instructions except AND and CPZ. Understand the use of the accumulator and symbolic variables and labels for jumps. Follow and be able to write short computational sequences and if-else or while-loop logic with Pip assembler code
6. Be able to convert individual instructions between assembler and machine language (both ways). I will post a table of op code to assembler mnemonic conversions, like 0010 MUL, so you do not have to put that in your notes. (and still be able to play computer on Pip assembler code).
7. Understand how millions of circuit elements can be created simultaneously in chip fabrication.
8. Be able to convert any way between Boolean expressions, sequential logic circuits, and truth tables.
9. Understand circuits for adders and multiplexers
10. SQL SELECT, WHERE with =, inequalities, LIKE '%...', IN, AND (not join – only one table at a time)

Exam emphases
1. Individual topics that are new since the last exam will be more emphasized than the topics you have been examined on before, probably meaning 45-55% of the exam will be on new topics.
2. Problems from later in the semester generally include skills needed from early in the semester implicitly, so most questions will not be straight from the early part of the course, though there may be some topics from earlier in the semester that did not get used much in the later part of the course.
3. The best characterization of the course is the course itself, but I have tried to give you tutorial work or homework on all topics, so reviewing your work is a good review. Looking at old exams or sample exams is a quick but not complete way to review the older material: You should have covered much more in all your work than there was space for in exams or even sample exams. Obviously if you missed something on an exam, it would be good to make sure you know it now, but exams involve a number of arbitrary choices and omissions, and different choices are likely to be made on the final. Major topics are likely to reappear, but often be treated from a somewhat different angle than last time, or combined in different ways. A mostly different collection of secondary topics is likely to be on the final.
4. I repeat: the best review of what you need to be able to do is to go over what you have worked on. If you need further exercises on any subject, let me know.

Same Instructions for studying and using the sample problems as on the last two exams
Study first and then look at the sample problems.... See earlier review pages for the rest of those instructions.

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
   
   Assem Opcode  Assem Opcode
   00010100 00000111  ADD  0000
   00000101 10000000  AND  1000
   00001111 00000000  DIV  0011

3. Convert the PIP Assembler to Machine code
   
   LOD 129
   MUL #3
   JMP 1100
   HLT

4. Play computer with the silly program below, completing the log at the right, showing the machine state after each instruction. To save time, you may choose to show only those values that change at each line. To be consistent with the simulator display, I show columns for both the current and next IP addresses, but you only need to fill in the current IP address (left column) of the instruction just executed. The initial values are shown.

<table>
<thead>
<tr>
<th>Address</th>
<th>Assembler code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>LOD # -5</td>
</tr>
<tr>
<td>2</td>
<td>STO X</td>
</tr>
<tr>
<td>4</td>
<td>MUL # -1</td>
</tr>
<tr>
<td>8</td>
<td>STO Y</td>
</tr>
<tr>
<td>8</td>
<td>CPL X</td>
</tr>
<tr>
<td>10</td>
<td>JMZ L1</td>
</tr>
<tr>
<td>12</td>
<td>LOD X</td>
</tr>
<tr>
<td>14</td>
<td>ADD Y</td>
</tr>
<tr>
<td>16</td>
<td>JMZ L2</td>
</tr>
<tr>
<td>18</td>
<td>L1: LOD X</td>
</tr>
<tr>
<td>20</td>
<td>L2: ADD X</td>
</tr>
<tr>
<td>22</td>
<td>JMP L3</td>
</tr>
<tr>
<td>24</td>
<td>SUB # 1</td>
</tr>
<tr>
<td>26</td>
<td>L3: HLT</td>
</tr>
</tbody>
</table>

5. Convert the following code to Pip Assembler.
   if X == Z:
       Y = 3
   else:
       X = Y
       Z = X + Y

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

7. Complete the truth table below.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>A'</th>
<th>A'B</th>
<th>A+B</th>
<th>A'B ⊕ (A+B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. Write a Boolean expression involving A, B, and C that corresponds to the following circuit:

![Circuit Diagram]

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

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>1</td>
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<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>1</td>
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<td>1</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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

```python
def foo(x):
    return x*2

def bar(a, n):
    print(foo(n+1))
    print(foo(a))
    print('go')

bar('now', 4)
```

12. Do the following base conversions. Show work.
   a. Convert the decimal number 54 into binary.
   b. Convert the binary number 11101001011001010 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 844 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`.

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

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

16. What is printed? Hint:

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

print(f(1), f(f(1)))
```
17. What is printed?
```python
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!
```python
for s in ['abc', 'de', 'f']:
    for ch in s:
        print(ch*2, end=' ')   #2
    print()                    #3
```

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

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

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

22. Write a function `printListUpper` that has a parameter `words`, which is a list of strings, and prints each string in upper case.
```python
def printListUpper(words):
```

23. Write a function `printListShortUpper` that has a parameter `words`, which is a list of strings, and prints each string that is shorter than the numeric parameter `n` in upper case. If `words` were ['hi', 'there'] and `n` were 4, then the following would be printed:
```python
HI THERE
```
```python
def printListShortUpper(words, n):
```

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

25. The start of a database table is shown. Write SQL queries:
```
<table>
<thead>
<tr>
<th>Classes</th>
<th>name</th>
<th>section</th>
<th>prof</th>
<th>time</th>
<th>credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comp 150</td>
<td>1</td>
<td>Harrington</td>
<td>TTh 10AM</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Comp 170</td>
<td>1</td>
<td>Akhtar</td>
<td>TTh 1PM</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Comp 363</td>
<td>1</td>
<td>Harrington</td>
<td>Th 4:15PM</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
```

a. Find the name and time for all classes with prof "Harrington"

b. Find the name, prof, and time of all classes for more than 3 credits.

Answers on the next page
Final Exam Review Problem Answers

1. LOD 130
   STO 131

2. LOD #7 ; pound sign from 0001; LOD code 0100; 7 from binary 00000111
   STO 128 ; STO code 0101; 128 in binary 10000000
   HLT ; HLT code is 1111

3. 00000100 10000001
    00100101 00000011
    00001111 00000000

4.
   IP--> ACCUM X Y
   ----------------
   -- 0 0 0 0
   0 2 -5 0 0 LOD #; 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=acc=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

5.  LOD X
    SUB Z ; same as if x-z == 0
    NOT ; same as if not x-z == 0
    JMZ ELSE
    LOD #3
    STO Y
    JMP PAST
ELSE: LOD Y
   STO X
PAST: LOD X
   ADD Y
   STO Z

6. (Could use NAND instead of AND and NOT)
   A
   B
   C
   CA
   B+(CA)'
   A(B+(CA)')

    |---|---|----|-----|-----|---------|
    | 0 | 0 | 1  | 0   | 0   | 0       |
    | 0 | 1 | 1  | 1   | 1   | 0       |
    | 1 | 0 | 0  | 1   | 1   | 1       |
    | 1 | 1 | 0  | 1   | 1   | 1       |

8.  | 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 |

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*16² + 10*16 + 15 = 512 + 160 + 15 = 687
   b. 844/16 = 52 R 12; 52/16 = 3 R 4; 3/16 = 0 R 3  Read remainders from right:  3  4 12; convert to
   hexadecimal digits: 34C.  (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.)

14.   1 111   carries
        101011
   + 100110
       1010001

15. [6, 2, 4, 9]
step by step
Line nums  i  comment
4   [6]  execution starts at line 4 -- after the definitions
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 and 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.  
12  
2  

<table>
<thead>
<tr>
<th>line</th>
<th>x</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>16/2 is 8</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>8&gt;3 and 8 &lt; 7 is true and false is false</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>print 8</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>8 &gt;2 is True</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>8/2 is 4</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4&gt;3 and 4 &lt; 7 is true and true is true</td>
</tr>
<tr>
<td>5</td>
<td>4*3 is 12 -- printed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4 &gt;2 is True</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>4/2 is 2</td>
</tr>
<tr>
<td>4</td>
<td>2&gt;3 and 2 &lt; 7 is false and true is false</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>print 2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2&gt;2 false: skip loop</td>
</tr>
</tbody>
</table>

18.  

<table>
<thead>
<tr>
<th>line</th>
<th>s</th>
<th>ch</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>abc</td>
<td></td>
<td>first in list</td>
</tr>
<tr>
<td>2</td>
<td>a</td>
<td></td>
<td>first in character sequence 'abc'</td>
</tr>
<tr>
<td>3</td>
<td>b</td>
<td></td>
<td>next in character sequence 'abc'</td>
</tr>
<tr>
<td>2</td>
<td>c</td>
<td></td>
<td>last in character sequence 'abc'</td>
</tr>
<tr>
<td>2</td>
<td>d</td>
<td></td>
<td>done with character sequence 'abc'</td>
</tr>
<tr>
<td>1</td>
<td>de</td>
<td></td>
<td>on to new line, done with inner loop</td>
</tr>
<tr>
<td>2</td>
<td>d</td>
<td></td>
<td>first in character sequence 'de'</td>
</tr>
<tr>
<td>2</td>
<td>e</td>
<td></td>
<td>next and last in character sequence 'abc'</td>
</tr>
<tr>
<td>2</td>
<td>f</td>
<td></td>
<td>done with character sequence 'de'</td>
</tr>
<tr>
<td>1</td>
<td>f</td>
<td></td>
<td>on to new line, done with inner loop</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>next in list for outer loop</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>next in line for outer loop</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>f</td>
<td></td>
<td>first in character sequence 'f'</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>done with character sequence 'f'</td>
<td></td>
</tr>
</tbody>
</table>

19.  

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

20.  

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

21.  

```python
def upper2(s):
    print(upper2ret(s))
```

22.  

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

23.  

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

24.  

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

25a  

```sql
SELECT name, time FROM classes
WHERE prof = "Harrington"
```

b.  

```sql
SELECT name, prof, time FROM classes
WHERE credits > 3
```