You are permitted 50 minutes to take this test, no more. This is an open book/open notes test. You are allowed the following items for the test: calculators, books, notes, homework, labs, pencils and erasers. You are not permitted to have any of the following on your desk during the test: computer, cell phone, or other electronic assistance. Failure to abide by this policy will result in a zero for the test and a visit to the UNC Charlotte honor board. Put your answers on this paper - use only this paper. Turn in this paper at the end of the test.

Please read and sign this statement: I have not received from anyone nor assisted others while taking this test. I have also notified the test proctor of any of these violations noted above.

Signature: ___________ Solution _____________

Multiple Choice - Questions 1-10: Each of these multiple choice questions is worth 4 points for a correct answer, 0 points for an incorrect answer. Circle your answers on this exam booklet. Multiple circles will be marked as incorrect.

1) Which of the following fully describes the outcome of the code at the right?
   a. Add all the numbers from 0 to 100 and put the result in sum.
   b. Add all the odd numbers from 0 to 100 and put the result in sum.
   c. Add all the even numbers from 0 to 100 and put the result in sum.
   d. Add all the odd numbers from N to 100 and put the result in sum.
   e. Add all the even numbers from N to 100 and put the result in sum.

   ```c
   int i, sum;
   sum = 0;
   i = 0;
   for(i=N; i<=100; i++){
     if(!(i % 2)) sum += i;
   }
   ```

2) A battery that is rated at 1200 mAhr is attached to a device that draws 125mA in active mode and 5mA in sleep mode. The device is in sleep mode for 50 min of every hour and in active mode for 10 min of every hour. How long will the battery last?
   a. 240.00 Hours
   b. 57.60 Hours - both accepted (answer is 48)
   c. 40.00 Hours
   d. 9.60 Hours
   e. 9.23 Hours

3) MCU can run in three modes: single chip, memory expansion, microprocessor modes. If used in single-chip mode what areas in memory could be addressed.
   a. Only internal areas (SFR, internal RAM, internal ROM) (p.25 of hardware manual)
   b. Internal areas (SFR, internal RAM, internal ROM) and external memory areas
   c. SFR, internal RAM and external memory
   d. SFR, external memory
   e. Only external memory

4) What is the number of address bits required to address any byte in a memory that contains 65536 bytes?
   a. 2 
   b. 8 
   c. 12 
   d. 16 
   e. 20
5) If I used the MCU30262 instruction ‘enter #2’ at the beginning of a function, how many bytes does the corresponding ‘exitd’ instruction deallocate from the stack if no other enter, exitd, jsr, pop or push operations are performed within the function?
   a. 6   b. 7   c. 8   d. 9   e. 10

6) Which assembly language code below adds the value of global variable shoe to the value in R1 and stores the result in R1:
   a. add.w shoe, R1
   b. add.w R1, shoe
   c. add shoe, R1
   d. add.w _shoe, R1
   e. add shoe + R1

Consider the piece of C-code to the right for questions 7 and 8:

7) How is the char b in the code passed to the function choosechar(a,b)?
   a. Stack
   b. R1L
   c. R1
   d. R1H
   e. None of the above

8) How is the int d passed in the function dothemath(c,d)?
   a. Stack
   b. R1L
   c. R1
   d. R1H
   e. None of the above

9) The double word 0x AC35 FA34 is stored in memory addresses N through N+3. Which of the following represents storage using big endianness?
   a. N 43
   b. N FA
   c. N AC
   d. N AC
   e. N 34
   f. N FA
   g. N FA
   h. N FA
   i. N AC
   j. N AC

10) Examine the assembly code at the right. This code corresponds to what C code?
   a. for(i=0; i<15; i++) x=x+2;
   b. when(x=0) x=x+2;
   c. x=0; while (x<16) x=x+2;
   d. x=0; x=x+2;
   e. switch(x) case 1: x=x+2;

      mov.w #0000H, -6[FB]
      L11:
      cmp.w #0010H, -6[FB]
      jge L12
      add.w #0002H, -6[FB]
      jmp L11
      L12:

Short Answer

11) What area of RAM is available for the user program on the SKP30262 board, assuming the monitor program is still used? List the range of addresses. (5 points)

   x00400 to x00B7F (x00B80 to x00BFF is used by monitor program) 5 points, all or nothing
12) Can you, the user, store a value at memory location 00CBCh? Why or why not? (5 points)

No, there is nothing there! (5 points, all or nothing)

13) Write M16C assembly code to implement the following C code. Assume X is in R1, Y is in R2, and Z is in R3. All data is 16 bits. (20 points)

```c
Z = 8;
X = 3;
while (X<Z) {
    Y++;
    X+=7;
}
```

```m16c
mov.w #8, R3
mov.w #3, R1
LOOP: cmp.w R3, R1
      jge EXIT
      add.w #1, R2
      add.w #7, R1
      jmp LOOP
EXIT:
...
```

5 points assign
5 points compare and branch
5 points adds
5 points loop control

14) Show how the following C arrays are laid out in memory for the M30262. Remember to pay attention to endianness, indicating which byte is located where. Assume the space for a starts in the first available space of user RAM (lowest address), and b starts 100 bytes (decimal) after where a starts. (20 points)

<table>
<thead>
<tr>
<th>Address</th>
<th>Array Element</th>
<th>Which byte?</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>a[0]</td>
<td>L</td>
</tr>
<tr>
<td>401</td>
<td>a[0]</td>
<td>H</td>
</tr>
<tr>
<td>402</td>
<td>a[1]</td>
<td>L</td>
</tr>
<tr>
<td>403</td>
<td>a[1]</td>
<td>H</td>
</tr>
<tr>
<td>404</td>
<td>a[2]</td>
<td>L</td>
</tr>
<tr>
<td>405</td>
<td>a[2]</td>
<td>H</td>
</tr>
<tr>
<td>406</td>
<td>a[3]</td>
<td>L</td>
</tr>
<tr>
<td>408</td>
<td>a[4]</td>
<td>L</td>
</tr>
<tr>
<td>409</td>
<td>a[4]</td>
<td>H</td>
</tr>
</tbody>
</table>

4 points 4 points 2 points
Correct  Correct H/L
Addresses Reference

<table>
<thead>
<tr>
<th>Address</th>
<th>Array Element</th>
<th>Which byte?</th>
</tr>
</thead>
<tbody>
<tr>
<td>464</td>
<td>b[0][0]</td>
<td>only</td>
</tr>
<tr>
<td>465</td>
<td>b[0][1]</td>
<td>only</td>
</tr>
<tr>
<td>466</td>
<td>b[1][0]</td>
<td>only</td>
</tr>
<tr>
<td>467</td>
<td>b[1][1]</td>
<td>only</td>
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<tr>
<td>468</td>
<td>b[2][0]</td>
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<tr>
<td>469</td>
<td>b[2][1]</td>
<td>only</td>
</tr>
<tr>
<td>46A</td>
<td>b[3][0]</td>
<td>only</td>
</tr>
<tr>
<td>46B</td>
<td>b[3][1]</td>
<td>only</td>
</tr>
</tbody>
</table>

4 points 4 points 2 points
Correct  Correct “only”
Addresses Reference
(row major)
15) Consider the following listing of a program compiled from C. It includes the original C source code as comments for clarity. Show the contents of the stack and registers R0, R1, SP and FB just before the exitd in $f2 executes. Also identify what each byte represents (e.g. LSB (least significant byte) of argument, MSB of variable, dynamic link, etc.). Assume that execution starts at the beginning of f1, at which point FB is 0804h and SP is 0800h. Assume that the address of the mov.w instruction following jsr $f2 is ff018h. Use ? to indicate values which are unknown or in boxes which are not used. (60 points)

```c
void f1(void) {
    enter #02H
    int a=10, b;
    mov.w #000ah,-2[FB] ; a
    mov.w -2[FB],R1 ; a
    jsr $f2
    mov.w R0,-2[FB] ; b
}

void f2(void) {
    int f2(int arg) {
        enter #02H
        mov.w R1,-2[FB] ; arg
        mov.w -2[FB],R0 ; arg
        add.w #0005H,R0
    }
}
```

<table>
<thead>
<tr>
<th>Address</th>
<th>Contents</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7f3</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>7f4</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>7f5</td>
<td>0ah</td>
<td>LSB arg f2</td>
</tr>
<tr>
<td>7f6</td>
<td>00h</td>
<td>MSB arg f2</td>
</tr>
<tr>
<td>7f7</td>
<td>feh</td>
<td>dynamic link LSB</td>
</tr>
<tr>
<td>7f8</td>
<td>07h</td>
<td>dynamic link MSB</td>
</tr>
<tr>
<td>7f9</td>
<td>18h</td>
<td>return address LSB</td>
</tr>
<tr>
<td>7fa</td>
<td>f0h</td>
<td>return address MSB</td>
</tr>
<tr>
<td>7fb</td>
<td>0fh</td>
<td>return address MSB</td>
</tr>
<tr>
<td>7fc</td>
<td>0ah</td>
<td>LSB of a, b</td>
</tr>
<tr>
<td>7fd</td>
<td>00h</td>
<td>MSB of a, b</td>
</tr>
<tr>
<td>7fe</td>
<td>04h</td>
<td>dynamic link LSB</td>
</tr>
<tr>
<td>7ff</td>
<td>08h</td>
<td>dynamic link MSB</td>
</tr>
<tr>
<td>800</td>
<td>??</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Register</th>
<th>Contents</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
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<td>4 pts</td>
</tr>
<tr>
<td>R1</td>
<td>000ah</td>
<td>4 pts</td>
</tr>
<tr>
<td>SP</td>
<td>07f5h</td>
<td>5 pts</td>
</tr>
<tr>
<td>FB</td>
<td>07f7h</td>
<td>5 pts</td>
</tr>
</tbody>
</table>

Contents: 2 points each correct value (including ?)

Description: 1 point for each correct value (including ?)