You may use your textbook and written notes from the course. There are 150 points possible, 10 per question.

1. Convert the assembly language instruction `MOVE.L D0,-(A3)` to machine code.
   a. Write your answer in binary in the boxes below.

   [Binary boxes]

   b. Convert to hexadecimal.

2. What will D0 contain after these two instructions finish:

   `MOVE.L #$FFEEDDCC,D0`
   `AND.W #$FF0F,D0`

3. Consider two possible ways to represent the time of day. In the first method, store the hour (0-23), minute (0-59) and second (0-59) as three separate numbers. In the second method, store the number of seconds elapsed since midnight (0-86399).

   How many bits does each method require?

4. George and Tommy decide they want to add expansion RAM to the 68KMB at address $20000. Their address decoder has three inputs: A17, LDS, and AS and one output: CS that activates the RAM chip. Their CS output should be active only when the three inputs are all active. Design a logic circuit to implement this.

5. The Superbowl has been played every year since 1967, and the NFL numbers them with Roman numerals: I, II, III, IV, V, ... A programmer working for the NFL needs to write a routine that figures out the Roman numeral string for a given superbowl. One way to do this is with a table lookup. What are the pros and cons of this approach?

6. Give a reason you might prefer BSR to JSR in a program.

7. Explain the difference between a trap and an interrupt.

8. Give an example of a 68000 instruction that has limited choices for addressing modes. Explain the limitations.
9. For each of these, say whether it is found in the 68000, the 8086, or both:
   a. The length (in words) of machine code instructions is variable.
   b. Support for parity checking is built-in
   c. Has 8 general purpose data registers
   d. Memory is broken into segments, and effective addresses are calculated using
      segment registers.
   e. Built-in support for a stack.

10. The MIPS microprocessor had only three addressing modes:
    Register direct
    Immediate
    Register indirect with offset.
    Show how you could accomplish the following 68000 instructions using (possibly
    more than one) 68000 instructions that use only those three addressing modes.
    a. MOVE.B D5,-(A2)
    b. MOVE.W D5,4(A1,D0)

11. Write a subroutine TERMIN8 that searches the string pointed to by A1 for an
    ASCII $0D character, then places the two characters $0A and $00 in memory
    immediately following.  For example, if A1 is $9000 and memory contains:
    00009000: 30 30 4F 4B 30 0D F0 F0 F0 F0 F0 F0 F0 F0 F0 F0 F0 F0 F0 F0
    then after the TERMIN8 subroutine, memory will contain:
    00009000: 30 30 4F 4B 30 0D 0A 00 F0 F0 F0 F0 F0 F0 F0 F0 F0 F0 F0

12. For real-time systems, interrupt “latency” is very important - this is the time
    between the generation of the interrupt and the start of the interrupt handler. On
    the 68000, interrupts are handled when the currently executing instruction
    completes.

    The slowest instruction on the 68000 is DIVS  xxx.L,Dn.  In addition, the
    exception handling for an interrupt takes 44 clock cycles.

    On a 68000 running at 4MHz, what is the worst case interrupt latency?

13. Which of these instructions require a memory write cycle?
    a. BSR  $A19
    b. CLR.B  (A0)
    c. RTE
    d. ROXL.L  #3,D0
    e. MOVEM.L  D0-D3/A2,-(SP)
14. Suppose the system stack contains the following:
   BFF2: 05A2
   BFF0: 0000
   BFEE: 2201 <- SSP is BFEE
An RTE occurs. What is the address of the next instruction to execute?
Will the system be in user or supervisor state?

15. Here are two loops that count the number of occurrences of the byte $2B$ between
    address $9000$ and $9FFF.
    * METHOD 1
    CLR.W D7 ;D7 counts bytes
    MOVE.L #$A000,A1 ;ending address
    MOVE.L #$9000,A0 ;start address
    LOOP CMP.B #$2B,(A0)+ ;check one byte
    BNE SKIP
    ADDQ.W #1,D7 ;found one, count it
    SKIP CMP.L A1,A0 ;end of range?
    BNE LOOP

    * METHOD 2
    CLR.W D7 ;D7 counts bytes
    MOVE.L #$2B,D0 ;byte to look for
    MOVE.L #$9000,A0 ;start address
    LOOP CMP.B D0,(A0)+ ;check one byte
    BNE SKIP
    ADDQ.W #1,D7 ;found one, count it
    SKIP CMP.L #$A000,A0 ;end of range?
    BNE LOOP

Which method is faster?

Write code to do the same thing, but is faster than both of these.