UNIVERSITY OF VICTORIA
EXAMINATIONS APRIL 1999

C SC 230 Computer Architecture and Assembly Language

NAME (print): ______________________________ REG NO. ________________

SIGNATURE: ______________________________ DURATION: 3 hours

INSTRUCTOR: D. M. Miller

TO BE ANSWERED ON THIS EXAMINATION PAPER.

STUDENTS MUST COUNT THE NUMBER OF PAGES IN THIS EXAMINATION PAPER BEFORE BEGINNING TO WRITE, AND REPORT ANY DISCREPANCY IMMEDIATELY TO THE INVIGILATOR.

THIS EXAMINATION HAS **TEN** PAGES PLUS THIS COVER PAGE.

ATTEMPT EVERY QUESTION. ANSWER IN THE SPACES PROVIDED (YOU DO NOT NECESSARILY HAVE TO USE ALL LINES PROVIDED AND MAY USE OTHER AREAS ON THE **FRONTS** OF THE PAGES IF NECESSARY). USE THE BACKS OF THE PAGES FOR ROUGH WORK.

THIS IS AN OPEN BOOK EXAMINATION. YOU MAY REFER TO THE TEXT MICROPROCESSORS AND MICROCOMPUTERS: HARDWARE AND SOFTWARE (FOURTH EDITION) OR ANY OTHER SINGLE TEXT, AND THE ASSEMBLER AND SIMULATOR GUIDES. NO OTHER AIDS, E.G. COURSE NOTES OR CALCULATORS, ARE PERMITTED.

QUESTION	MAX. MARK	STUDENT'S MARK
1	10	
2	4	
3	8	
4	15	
5	13	
6	12	
7	16	
8	7	
9	7	
10	6	
11	2	
TOTAL	100	

1. (10 marks) Circle the correct answer for each of the following:

(a) The 8-bit two's complement representation of 7_{10} is 11111001_2.	True	False
(b) In 2's complement arithmetic, overflow occurs when the result value is too large for the number of data bits available.	True	False
(c) A Hamming code allows the detection of up to 3 bit errors and the correction of 1 and 2 bit errors.	True	False
(d) On the 6811, the external address and data buses are synchronous.	True	False
(d) Memory-mapped I/O eliminates the need for dedicated I/O instructions on a processor.	True	False
(f) A processor must have a hardware stack in order to support a jump to subroutine as a single instruction.	True	False
(g) Unless explicitly programmed by the user, maskable interrupts can not interrupt each other on the 6811.	True	False
(h) The 6811 is an example of a CISC design.	True	False
(i) The PENTIUM is an example of a RISC design.	True	False
(j) The PENTIUM II uses SIMD techniques to implement MMX	True	False

2. (4 marks) For the single precision IEEE floating point representation for -12.125_{10}

What is the value of the sign bit: ____

What is the value actually stored for the exponent (in decimal): ________

What is the value actually stored for the mantissa (in binary): ____________________

(do not show trailing 0's)

3. (8 marks) Consider the following program:

```
        org   $C000
numb    rmb   2
start   lds   #$FF
        ldd   #1027
        std   numb
loop    ldx   #numb
        pshx
        jsr   div4
        ins
        ins
        ldd   numb
        cpd   #32
        bhs   loop
        stop
```

(continued on next page)

(a) Write the subroutine "div4" so the parameter passed to it is divided by four each time "div4" is executed. This should be an integer division which returns the quotient without rounding. Note that the subroutine accepts one parameter on the stack. Your subroutine should be as efficient as possible. Registers should be protected.

(b) How many times is subroutine "div4" executed by the program above?

4. (15 marks) You are to write a subroutine called CONVERT with no parameters that inputs a decimal number by reading ASCIII characters from the keyboard using the monitor routine INCHAR (address $FFCD). Recall that INCHAR returns one character in register A each time it is called. You can assume the user only types decimal digits and a single terminating blank. Your subroutine CONVERT is to return with the value read in register D. For example, if the user typed 257 followed by a blank, then D contain $0101 on return from CONVERT. Your subroutine should protect registers X and Y. The decimal digits have ASCII codes $30 - $39.

5. (13 marks)
Consider the following program:

```
;The sum of the elements of the array "arr" is placed in the location
;labelled "total".
          org     $8000
arr       fcb     121,124,169,85,38
total     rmb     2
          org     $9000
          lds     #$01FF
          ldx     #arr
          ldy     #5
          jsr     sum
          std     total
          stop

;Subroutine sum receives the number of elements to be totaled in register Y
;and the array address in register X. It leaves the result in register D.
sum       ldd     #0
loop      cpy     #0
          beq     end
          addb    0,x
          adca    #0
          inx
          dey
          bra     loop
end       rts
```

(a) What is the content of accumulator A on exit from subroutine “sum”? ________

(b) What is the content of index register X on exit from subroutine “sum”? ________

(c) The above program passes its parameters, both input and output, via registers. You are to modify it to pass the parameters via the stack. There are to be three parameters which in order are: (1) the address of the array of values; (2) the number of values to be totaled; (3) the address of the location where the result is to be placed. Parameter (1) is to be on top. You are to make the additions necessary to the main program and the subroutine.

You are also to add any instructions necessary to ensure all accumulator and index registers used by the subroutine are protected.

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```
;The sum of the elements of the array "arr" is placed in the location
;labelled "total".
        org     $8000
arr     fcb     121,124,169,85,38
total   rmb     2
        org     $9000
        lds     #$01FF

        ______________
        ______________
        ______________
        ______________
        ______________
        jsr     sum
        ______________
        ______________
        ______________
        ______________
        ______________
        ______________
        stop

; sum receives three parms on the stack: the address of an array (on top)
; the number of values to be totaled and the address of the location
; to hold the result
sum     ______________
        ______________
        ______________
        ______________
        ______________
        ______________
        ______________
        ldd     #0
loop    cpy     #0
        beq     end
        addb    0,x
        adca    #0
        inx
        dey
        bra     loop
end     ______________
        ______________
        ______________
        ______________
        ______________
        rts
```

6. (12 marks)

A push-button is connected as an input to IC3. You are to write a subroutine that **polls** IC3 until the button has been pressed (a rising edge on IC3). Once the rising edge occurs, your subroutine is to light a LED at Port A bit 5 for 1 second. After the one second, your subroutine turns off the LED and returns. Your subroutine should protect the accumulator and index registers it uses. Use OC3 for timing the one second. Use **polling** for OC3. Assume a 2MHz processor clock and recall there are 1000 milliseconds in a second. Use the usual control register names such as TFLG1, TOC2 etc. without defining them.

Show any initialization needed outside the subroutine in the space provided.

Initialization outside subroutine:

Subroutine:

7. (16 marks)
Complete the following stop watch program so it behaves as described. Note it is not the same as the one you did for assignment 5. The routines ZERO and NDISPLAY are not shown for brevity. You do **not** have to write them. Assume the processor has a 2MHz clock.

```
; This is a stop watch program that times in 1/10's of a second.
; The watch is in one of three states:
;      state 0 stopped with the time at 0 (initial state)
;      state 1 running
;      state 2 stopped with the time held at the time it was stopped
;
; The watch starts in state 0.  A rising edge on IC3 takes the watch
; to the next state in order 0 -> 1 -> 2 -> 0 etc.  So the first IC3
; event starts the watch.  A second one stops it, and a third one
; resets it to 0.
;
; OC2 interrupts are used for timing.

REGBASE  EQU   $1000
TCNT     EQU   $0E
TIC3     EQU   $14
TOC2     EQU   $18
TCTL2    EQU   $21
TMSK1    EQU   $22
TMSK2    EQU   $24
TFLG1    EQU   $23
IC3F     EQU   $01
OC2F     EQU   $40

; Timing control so watch counts in tenths of a second
SLICE    EQU   _______
TIMECNT  EQU   _______

; Global variables
COUNT    RMB   1       / OC2 INTERRUPT COUNT
TIME     RMB   2       / TIME IN 0.1 SECS
STATE    RMB   1       / WATCH STATE

; Interrupt jump table entries
      ____________________
      ____________________
      ____________________
      ____________________

         ORG   $C000
START    LDS   #$01FF
         LDX   #REGBASE
         CLR   STATE       / WATCH IS INIT STOPPED
         JSR   ZERO        / AND ZEROED
         LDAA  _______     / SET IC3 EDGE TYPE TO RISING
         STAA  _______
         LDAA  _______     / ENABLE IC3 INTERRUPTS
         STAA  _______
         _____             / ENABLE INTERRUPTS
```

(*continued on next page*)

```
LOOP     LDY    TIME        / DISPLAY TIME
         PSHY
         JSR    NDISPLAY
         INS
         INS
         BRA    LOOP
;==============================================================
; IC3 INTERRUPT

IC3      LDX    #REGBASE
         LDAA   ________      / CLEAR IC3 EVENT FLAG
         STAA   ________
         INC    STATE         / ADVANCE STATE
         LDAA   STATE
         CMPA   #1
         BEQ    IC31
         CMPA   #2
         BEQ    IC32
         CLR    STATE         / -> STATE 0 SO CLEAR TIMER
         JSR    ZERO
         RTI
IC31     LDD    ________      / -> STATE 1 SO SET TOC2
         ADDD   ________
         STD    TOC2,X
         BSET   ____________  / ENABLE OC2 INTERRUPT
         CLR    COUNT
         RTI
IC32     BCLR   TMSK1,X ____  / -> STATE 2 SO DISABLE OC2 INTERRUPT
         RTI
;==============================================================
; Time is kept by counting oc2 interrupts spaced SLICE cycles
; apart.  It takes TIMECNT slices to make 1/10 of a second.
; This handler affects the global variables COUNT and TIME.

OC2      __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________
         __________________

         RTI
```

8. (7 marks)
   (a) What is the purpose of the start bit in asynchronous serial communication?

   ____

   ____

   (b) What is the purpose of the parity bit in asynchronous serial communication?

   ____

   ____

   (c) Draw the bit pattern that would be sent for the ASCII character X ($58) assuming 7 bits, even parity with one stop bit. Draw vertical lines to separate the bits.

9. (7 marks)
   (a) What is the advantage of having separate fixed-point and floating point processors in a CPU?

   ____

   ____

   (b) Briefly explain how the compiler assists branch prediction on the Power-PC.

   ____

   ____

   ____

10. (6 marks)
    Consider the diagram on the next page (it is not identical to the one shown in class):

    (a) How many bytes of memory does the RAM chip have? ____________

    (b) What range of addresses does the RAM chip occupy?

    ____

    (c) Which component(s) would not be needed if the 68HC11 had separate address and data busses?

    ____

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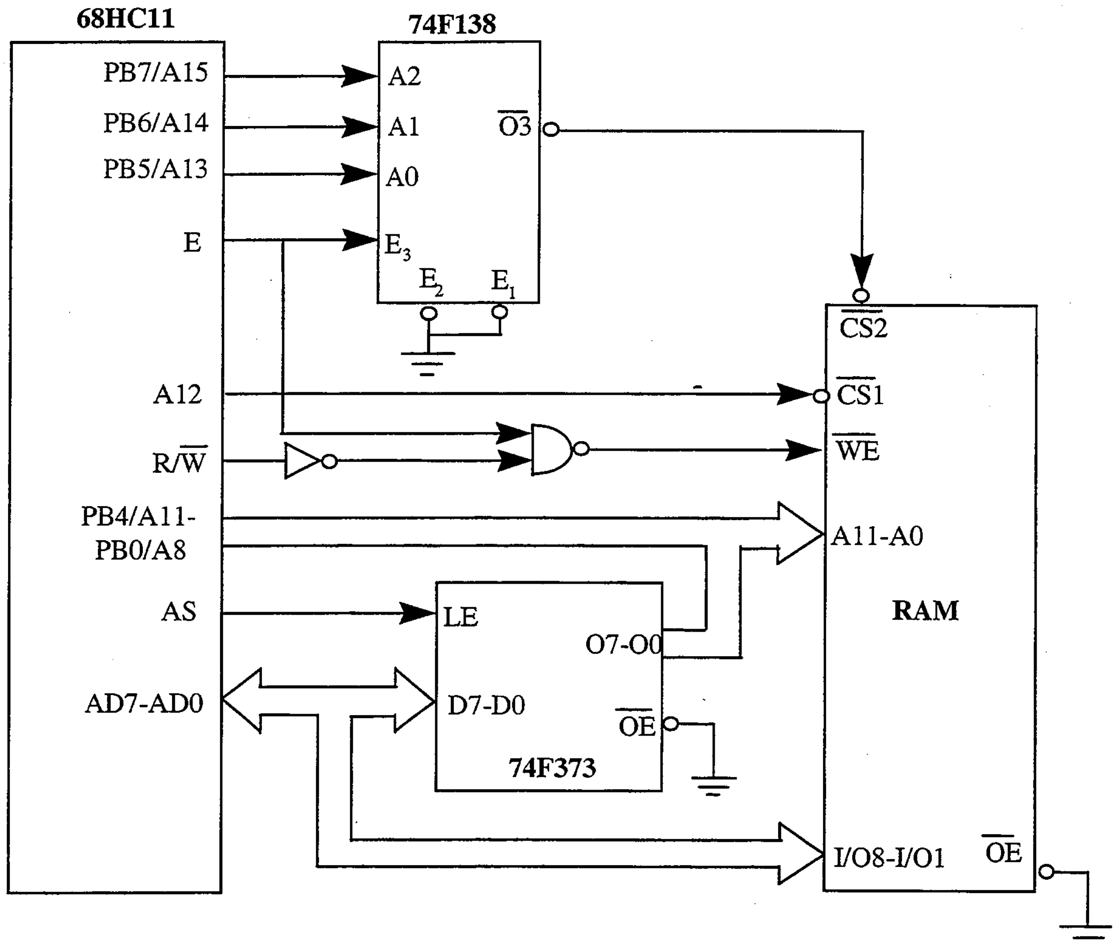

11. (2) What does the term superscalar mean with respect to processor design?

____

____

____

***** End of Examination *****

Note: *Course marks to date are posted on the web. Please check your marks and notify Dr. Miller of any errors or omissions by April 19.*