EE 308

Final Exam

May 13, 1999

Name: _____

You may use any of the Motorola data books and two pages of notes. No calculators allowed. Show all work. Partial credit will be given. No credit will be given if an answer appears with no supporting work. **For all the questions below, assume the 68HC12 has a 16 MHz crystal which results in a 8 MHz E clock. For all the C code you write assume `hc12.h` has been included so you can refer to registers by name.**

1. For this problem assume all the arithmetic is done with an eight-bit processor.

   (a) Fill in the blanks in this table.

Hex	Binary	Unsigned Decimal	Signed Decimal
23			
	10010110		
			-17

   Consider the following HC12 instructions. Show the result in the `A` accumulator, and indicate the state of the `N`, `Z`, `V` and `C` bits after executing both instructions. The answer should be in hexadecimal.

   (b)
```
ldaa #$C8
adda #$A9
```
   Answer: _____ N: _____ Z: _____ V: _____ C: _____

   (c)
```
ldaa #$77
adda #$48
```
   Answer: _____ N: _____ Z: _____ V: _____ C: _____

   (d)
```
ldaa #$C8
suba #$A9
```
   Answer: _____ N: _____ Z: _____ V: _____ C: _____

2. Consider the following program fragment:

Address		Op Code & Operands	Addressing Mode	Cycles
----	CODE: section .text			
----	org $0800			
	ldd #$C217			
	anda #$82			
	stab $0955			
	inc $55			
	pshx			

(a) Fill in the above table. In the column labeled `Address`, fill in the address of the first byte of the instruction. In the columns labeled `Op Codes & Operands` show the op codes and operands (as hex numbers). In the column labeled `Addressing Mode` indicate the addressing mode used by the instruction. In the column labeled `Cycles` indicate the number of cycles needed to execute the instruction.

(b) How many bytes of memory does the code fragment occupy?

(c) How many microseconds will it take the fragment to execute on an HC12 with a 8 MHz E-clock?

(d) For the same instructions show the values of each of the registers after execution of the instruction. You do not have to put down a value if the value did not change. You do not have to indicate the state of the `H` bit of the `CCR`.

Inst	A:B	X	Y	SP	PC	CCR S X H I N Z V C
	FF:FF	FFFF	FFFF	0A00	0800	1 1 1 1 1 1 1 1
ldd #$C217						X
anda #$82						X
stab $0955						X
inc $55						X
pshx						X

3. The following tables show the values of an HC12's registers and some of its memory.

Reg	-	-
CCR	S X H I N Z V C 1 0 0 0 1 0 0 1	
A:B	A3	92
X	82F2	
Y	12F7	
SP	208D	
PC	31F4	

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0800	C6	05	CE	09	00	DD	5A	33	6A	05	08	53	26	F7	3F	CE
0810	E0	00	CD	00	00	E6	00	0F	00	01	02	19	ED	08	8E	E0
0820	20	25	F2	7A	09	00	3F	CF	0A	00	15	FA	00	01	5F	A0
0830	01	3F	C6	80	5B	86	C6	03	5B	8D	C6	FF	5B	02	4C	80
FFD0	20	20	20	30	20	40	20	50	20	60	20	70	20	80	20	90
FFE0	21	A0	21	B0	30	D0	32	F0	21	00	21	10	21	20	21	30
FFF0	20	A0	21	50	21	60	21	70	21	80	21	90	21	A0	C5	A3

(a) What is the address of the first instruction the HC12 will execute after a reset? _____

(b) What is the address of the Real Time Interrupt interrupt service routine? _____

(c) Is the XIRQ interrupt enabled? How can you tell? _____

(d) Reverse assemble the first four instructions starting at address 0x0800. Write down the mnemonic and operand for the instructions. Indicate the addressing mode used. Also indicate the effective address – i.e., the address in memory which the instruction will use to fetch or store the number it is working on.

Instruction Address	Mnemonic	Operand	Addressing Mode	Effective Address

4. Assume the HC12's registers have the following values:

Reg	-	-
	S X H I N Z V C	
CCR	1 0 0 0 1 0 0 1	
A:B	A3	92
X	82F2	
Y	12F7	
SP	208D	
PC	31F4	

(a) Briefly explain the purpose of the stack on the HC12.

(b) Explain what happens to the stack, stack pointer, and program counter when you execute the following instruction:

```
pshx
```

(c) If the registers started with the values shown above, tell what registers and memory locations will have been changed after executing the `pshx` instruction. What will the new values be?

5. Here are some questions about various sub-systems on the HC12.

   (a) What is the `TCNT` register?

   (b) Explain the function of the prescaler in the timer subsystem.

   (c) Briefly explain the concept of the input capture function.

   (d) Briefly explain the concept of the real time interrupt.

   (e) Write some C code to set up the A/D converter to make conversions of Port AD Bit 3, continuously.

   (f) Assume V_{RH} = 4 V and V_{RL} = 0 V. The voltage on the pins of Port AD are shown in the table below. What will be the value in the `ADR1H` register after the completion of the A/D conversions started by part (e)?

AD0	AD1	AD2	AD3	AD4	AD5	AD6	AD7
0.5 V	1.0 V	1.5 V	2.0 V	2.5 V	3.0 V	3.5 V	4.0 V

   (g) What is a flag in the sense used by the HC12 hardware?

   (h) How do you clear flags in the timer subsystem? Give an example by writing some C code to clear `C2F`.

   (i) How do you clear flags in the serial peripheral interface subsystem? Give an example by writing some C code to clear `SPIF`.

   (j) Assume the HC12's SPI has been enabled, and the SPI is operating in master mode. When you write a byte to `SP0DR`, then read the value of `SP0DR` the value you read is usually different than the value you wrote. Why?

6. Below are the values of some timer registers in the HC12:

TIOS	OC7M	OC7D	TSCR	TCTL1	TCTL2	TCTL3	TCTL4	TMSK1	TMSK2	TFLG1	TFLG2
B5	31	60	80	A4	C2	5F	76	47	03	21	80

(a) Which timer interrupts are enabled?

(b) Which timer flags are set?

(c) Briefly explain how a timer output compare function works.

(d) Which timer channels are set up for output compare?

(e) Which output pins will OC7 control?

(f) What will happen to these pins when `TCNT = TC7`?

(g) How long (in seconds) will it take for the TCNT register to overflow?

(h) Write some C code to set up timer channel 3 to function as an input capture pin, capture the time of the falling edge on Port T3, and generate an interrupt on the falling edge.

(i) Write some C code to set up PWM channel 3 to operate with a 100 Hz frequency and a 20% duty cycle.

7. Consider the following code fragment:

```
DDRS = DDRS | 0xE0;              /* Instruction 1 */
PORTS = PORTS | 0x80;            /* Instruction 2 */
SP0BR = 0x04;                    /* Instruction 3 */
SP0CR1 = 0x5a;                   /* Instruction 4 */
PORTS = PORTS & ~0x80;           /* Instruction 5 */
SP0DR = 0x5a;                    /* Instruction 6 */
while ((SP0SR & 0x80) == 0) ;    /* Instruction 7 */
PORTS = PORTS | 0x80;            /* Instruction 8 */
```

(a) Explain the purpose of each instruction:

i. Instruction 1:

ii. Instruction 2:

iii. Instruction 3:

iv. Instruction 4:

v. Instruction 5:

vi. Instruction 6:

vii. Instruction 7:

viii. Instruction 8:

(b) Draw a timing diagram showing what happens on the `SCK`, `MOSI`, and `SS` lines of the HC12 when it executes instructions 4 through 7.

(c) For the question above, what is the speed of the `SCK`?

8. For this problem, assume the HC12 is in single-chip mode – i.e., Ports A and B are used for parallel I/O, and no external memory or peripherals are attached to the chip.

   (a) List at least six things which you need to do in software to be able to use interrupts on the HC12.

   i.

   ii.

   iii.

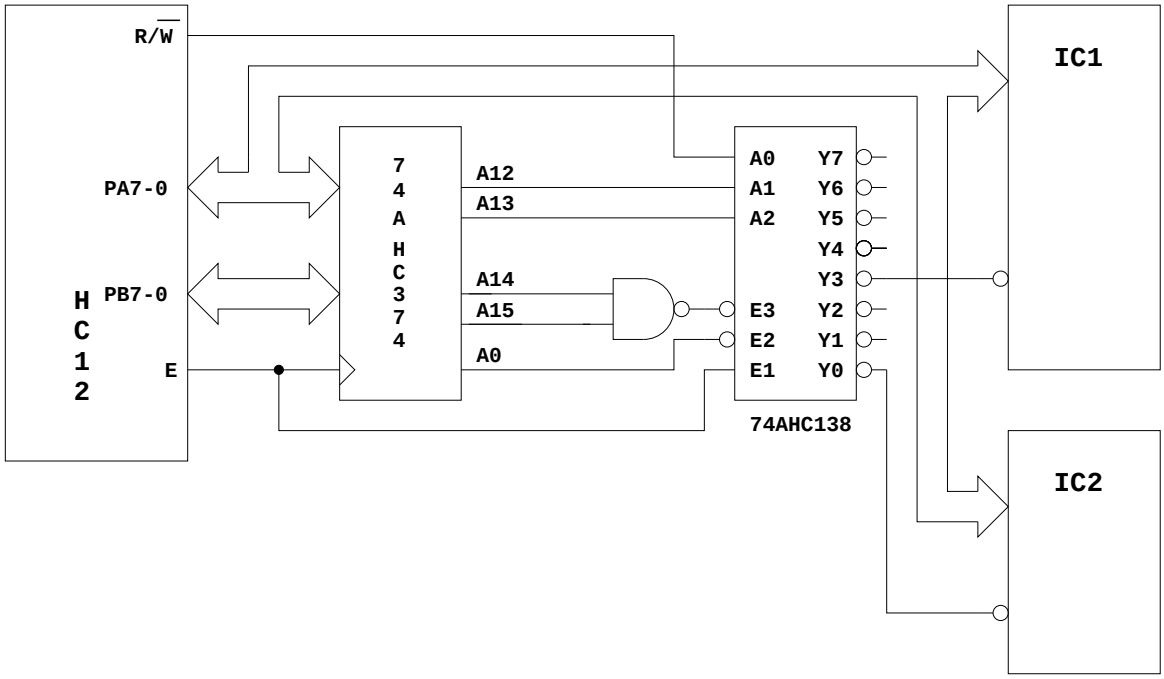
   iv.

   v.

   vi.

   (b) Write a C program which will use the timer overflow interrupt to increment Port A. The TOF interrupt should be called once every 16.384 ms.

9. The following figure shows some external hardware connected to an HC12 in expanded mode.



(a) Explain the function of the HC12's Port A and Port B in wide expanded mode.

(b) Explain the function of the 74HC374 chip in the interface.

(c) What range of addresses access IC1 – i.e., for what range of addresses will `CS_1` be low? Is this an input or output device?

(d) What range of addresses access IC2 – i.e., for what range of addresses will `CS_2` be low? Is this an input or output device?

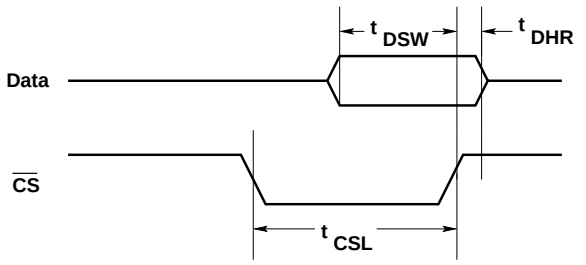
(e) Write a C `#define` which allows you to use the name `MY_OUTPUT` to access a 16-bit output port at address 0x2000.

```
#define MY_OUTPUT _____________________________
```

(f) Using the above define write a line of C code which will write the value `0xa55a` to the 16-bit output port at address 0x2000.

10. The chip which is an output device has a timing diagram as shown.

IC? WRITE TIMING



t_{DSW}	= 30 ns Min	Data Setup Write
t_{DHW}	= 20 ns Min	Data Hold Write
t_{CSL}	= 100 ns Min	Chip Select Low, Write

(a) On the figure above, add timing signals from the HC12 and the 374 and 138 which generate the chip select for the output chip.

For each of the timing values, explain in words what the timing parameter means. Determine if the time is compatible with the HC12 in the circuit shown on the previous page. Assume the propagation delays through the 74HC138 and 74HC373 are 10 ns. Indicate which circled number(s) from the HC12 Electrical Characteristics Manual you used in determining whether the chip is compatible with the HC12. If the time is not compatible, determine whether it will be compatible with the addition of an E-clock stretch.

(b) t_{DSW}

Description:

Actual Time : _____ Circled Number: _____ Compatible? ____ OK with stretch? _____

(c) t_{DHW}

Description:

Actual Time : _____ Circled Number: _____ Compatible? ____ OK with stretch? _____

(d) t_{CSL}

Description:

Actual Time : _____ Circled Number: _____ Compatible? ____ OK with stretch? _____