Midterm Winter 2004
SYSC 2003 Computer Organization Section A
Department of Systems and Computer Engineering

Name : _____ Total : _____/ 40

Student Number : _____

A summary of basic HC12 assembly instructions is provided on the back page.

Question 1 [8 marks] Write brief answers.

a) [2 marks] What is a microcontroller ?

b) [2 marks] Embedded systems generally suffer from small memories. Give one specific example of an instruction or addressing mode that shows how the HC12 has optimized its instruction encoding for space.

c) [2 marks] How does a cross-assembler differ from an assembler ?

d) [2 marks] Both of the following statements cause the value $0300 to be stored in location $1000, but at different times. Explain the difference.

```
    org $1000
var DW  $0300        and        MOVW #$0300, $1000
```

Question 2 [20 marks]

a) [2 marks] Write a **single** assembly instruction that performs the same operation as this sequence :

```
LDAA  variable
ANDA #$03
STAA variable
```

f) [8 marks] Complete the following assembly program that computes the volume of a sphere with an (unsigned) byte diameter. The volume is represented as a 32-bit unsigned number. The computation being performed is :

volume = PI * diameter^3 / 6 where PI is approximated by 355/133.
The program rearranges the equation in an attempt to minimize loss of precision by performing as many multiplications as possible before dividing.

Your solution must use the HC12 instructions properly. Use the comments as your guide.

```
        org $4000
        bra compute
diameter:   db 255
volume:     rmw  _______
compute:
        _______ diameter        ; Compute diameter^2
        _______ diameter
        MUL
        TFR D, ____             ; Compute diameter^3 = diameter * diameter^2
        LDAB diameter
        CLRA
        EMUL

        _______ #113*6          ; Compute diameter^3/ (113*6 )
        EDIV

        _______ #355            ; Compute (diameter^3/ (113*6)) * 335
        EMUL

        _______ volume          ; Store computed value in volume
        STD _______
        SWI                     ; Done.
```

c) [10 marks] Below is a short memory dump. Suppose that PC=$4000, and **all** the instructions in the following listing are now executed. Answer the related questions. *Show your work for partial marks.*

4000: FC 40 0D 83 FF BF 28 03 FC 7F FF 20 02 8F 31 3F

```
1:
2:          =00004000                       org $4000
3:
4:
5:      4000 FC 400D                        LDD     x
6:      4003 83 _____                       SUBD    #$FFBF
7:      4006 28 _____                       BVC     next
8:      4008 CC _____                       LDD     #$7FFF
9:      400B 20 02                  next:   BRA     done
```

a) [2 marks] Is the variable 'x' a signed or unsigned quantity. Justify.

b) [3 marks] Fill in all blanks (_____) in the listing above.

c) [2 marks] What is the hexadecimal value in register D now ?

d) [3 marks] What is the current PC after executing the sequence?

Question 3 [12 marks] Write the assembly implementation of the following subroutine using the course policies for assembly subroutines. Pass parameters on the stack.

```
void convert( byte value, char &ascii[8] )
// Returns an array of 8 characters containing the ASCII representation of the
// unsigned binary value.
```

Example : If the value is $FC, the returned array = {'1','1','1','1','1','1','0','0'}.

Do not worry about a terminating character.

Tip : This question has two components : (1) subroutines and (2) ASCII conversion. If you don't know how to do the ASCII conversion, you can still write the outline for your subroutine to demonstrate your knowledge of parameters passing and thereby gaining part marks.