DUBLIN INSTITUTE OF TECHNOLOGY
KEVIN STREET DUBLIN 8

BSc. (Honours) Degree in Computer Science

Year 1

Semester 2 Examinations 2013/2014

Microprocessors

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Wednesday 24th May 4.00 p.m. – 6.00 p.m.

Answer 3 out of the following 4 questions.
Numbers prefixed by *0x* are in hexadecimal.

Question 1:

(a) Using your calculator or otherwise, determine the 32 bit results of the following calculations. Express your answer in hexadecimal

(i) 0xb3314a5b AND 0x2417ffce [3]

(ii) 0x8a293dce OR 0x753e2170 [3]

(iii) 0x7231a3bf XOR 0x1248a8e2 [3]

(b) What is the hexadecimal representation of the 32 bit number -5? [4]

(c) What are the **decimal** signed numeric ranges for the following:

(i) 8 bit numbers [2]

(ii) 12 bit numbers [2]

(iii) 24 bit numbers [2]

(d) Write a C function that converts a 32 bit unsigned integer value into a null terminated ASCII decimal string. For example, the value 12345678 should be converted to the ASCII string "12345678". The function prototype is as follows:

```
void IntToString(unsigned int val, char *String);
```

[9]

Question 2:

(a) Port 0 of the LPC1114 is associated with two registers : GPIO0DIR and GPIO0DATA.

(i) State the function of each of these registers [4]

(ii) An LPC1114 microcontroller program is required to set BIT5 of General Purpose IO Port 0 without affecting the other bits. Show how you would do this in a line of C-code [4]

(iii) An LPC1114 microcontroller program is required to clear BIT2 of General Purpose IO Port 0 without affecting the other bits. Show how you would do this in a line of C-code [4]

(iv) An LPC1114 microcontroller requires bits 2 and 5 of General Purpose IO Port 0 to be outputs, all other bits to be inputs. Show how you would program this in C. [4]

(v) An LPC1114 microcontroller program is required to wait for bit 6 of General Purpose IO Port 0 become logic 1. The states of the other bits is not known in advance. Show how you would program this in C. [4]

(b) Listing Q3a contains C-code partially decodes a multiplexed matrix keypad.

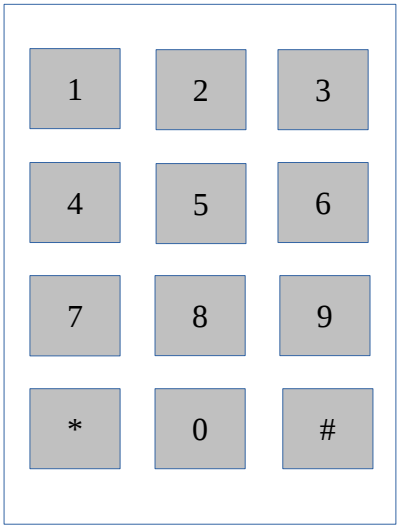
(i) Explain how multiplexing can be used to reduce the number of pins required to interface to a matrix keypad [8]

(ii) Complete the code so that the ScanKeys function decodes all three columns. [5]

```
// Keypad is on Port 1
// Define wiring of port bits
#define COL_1     BIT5
#define COL_2     BIT9
#define COL_3     BIT3
#define ROW_1     BIT8
#define ROW_2     BIT1
#define ROW_3     BIT2
#define ROW_4     BIT4

char ScanKeys()
{
      GPIO1DATA |= COL_1 | COL_2 | COL_3;
      GPIO1DATA &= ~COL_1;
      if ((GPIO1DATA & ROW_1) == 0)
            return '1';
      if ((GPIO1DATA & ROW_2) == 0)
            return '4';
      if ((GPIO1DATA & ROW_3) == 0)
            return '7';
      if ((GPIO1DATA & ROW_4) == 0)
            return '*';

      GPIO1DATA |= COL_1 | COL_2 | COL_3;
      GPIO1DATA &= ~COL_2;
      if ((GPIO1DATA & ROW_1) == 0)
            return '2';
      if ((GPIO1DATA & ROW_2) == 0)
            return '5';
      if ((GPIO1DATA & ROW_3) == 0)
```



```
            return '8';
      if ((GPIO1DATA & ROW_4) == 0)
            return '0';

// Insert missing missing from here.
      return 0;
}
```

Question 3:
Translate the following C code fragments into the ARM Thumb instruction set used on the LPC1114 microcontroller.
(a)

```
// global variables
int i;                                                    [2]
int k;

k=1;                                                      [2]
for (i=0;i<10;i++)                                        [5]
        k = k * 2;                                        [3]
```

(b)
(i) What is the effect of the “register” modifier used in variable declarations in C? [2]

(ii) What is the effect of the “volatile” modifier used in variable declarations in C? [2]

(iii) The contents of an Input/Output port are to be represented by the symbol PORT_DATA. The port is memory mapped and is at memory location 0x50003ffc. Show how you would declare this symbol in C. You may assume that the underlying data type involved is an **int**. [4]

(c)
Describe what is meant by each of the following terms in computer systems
(i) Clock [2]

(ii) Timer [2]

(iii) Interrupt [2]

(iv) Interrupt Service Routine [2]

(v) Interrupt Vector Table [2]

(vi) Outline the operation of a software/hardware based system that causes the CPU to execute a particular function at a known, predictable rate. [3]

Question 4:

(a) What is the principal function of the following ARM Cortex M0 registers?
(i) PC [2]

(ii) LR [2]

(iii) SP [2]

(iv) PSR [2]

(b) What ARM Cortex M0 Arithmetic flags are set by the following calculations

(i) 1-1 [2]

(ii) 0xfffffff9+12 [2]

(iii) 1-2 [2]

(iv) 0x7fffffff+2 [2]

(c) Listing Q4a contains an ARM assembly language program for use on an ARM Corted M0 processor.
(i) Which instruction is executed first following reset? [2]

(ii) Citing two examples, explain what is meant by the term **assembler directive?** [3]

(iii) Describe in detail the effect of the instructions on lines marked A,B,C and D [12]

Listing Q4a

```
Result SPACE 4      ; allocate space for the result
Stack  SPACE 0x100  ; allocate some space for the stack

     AREA THUMB,CODE,READONLY
     ; EXPORTED Symbols can be linked against
          EXPORT Reset_Handler
          EXPORT __Vectors
     ; Minimal interrupt vector table follows
     ; First entry is initial stack pointer (end of stack)
     ; second entry is the address of the reset handler
__Vectors
          DCD Stack+0x100
          DCD Reset_Handler
     ; Define some constant operands
Num1   DCD 1
Num2   DCD 6
     ; 'Main' program goes here
Reset_Handler
          BL main
```

```
stop B  stop

main
          PUSH {R0,R1,R2,LR}  LINE A
          LDR R1,=Num1        LINE B
          LDR R2,=Num2
          LDR R0,[R1]
          LDR R1,[R2]
          ADDS R0,R0,R1       LINE C
          LDR R1,=Result
          STR R0,[R1]
          POP {R0,R1,R2,PC}   LINE D
     end
```