DUBLIN INSTITUTE OF TECHNOLOGY

BSc. (Honours) Degree in Computer Science

Year 1

SUMMER EXAMINATIONS 2014/2015

MICROPROCESSORS [CMPU1019]

MR. F. DUIGNAN
DR. D. LILLIS

WEDNESDAY 20TH MAY 4.00 P.M. – 6.00 P.M.
TWO HOURS

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

In addition to the DIT Approved List of Calculators (Use of Calculators in Examinations), the following calculator models are also permitted for this examination:	
Casio fx-991es	Casio fx-991es PLUS
Sharp EL-520X	Sharp EL-520W
Sharp EL-W506	Sharp EL-506x

Question 1:

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

(i) 0x7a4b21e0 XOR 0x89ef3721 [3 marks]

(ii) 0x6decb839 OR (~0xfe309130) [3 marks]

(iii) 0x112387f1 AND 0xeaf90196 [3 marks]

(b) What is the hexadecimal representation of the 32 bit number -7? [4 marks]

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

(i) 10 bit numbers [2 marks]

(ii) 16 bit numbers [2 marks]

(iii) 24 bit numbers [2 marks]

(d) Exactly how many bytes are there in 10MiB? [2 marks]

(e) A microcontroller has a 10 bit Analogue to Digital Converter (ADC). The ADC can accept voltages in the range 0 to 3Volts

(i) What is the function of ADC's in microcontrollers? [4 marks]

(ii) A C function is available called ReadADC(). The function returns ADC conversion results as a 10 bit number. If the function returns a value of 400, what voltage was applied to the input of the ADC?

[8 marks]

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 marks]

(ii) An LPC1114 microcontroller program is required to toggle BIT7 of General Purpose IO Port 0 without affecting the other bits. Show how you would do this in a single line of C-code [4 marks]

(iii) An LPC1114 microcontroller program is required to clear BIT8 of General Purpose IO Port 0 without affecting the other bits. Show how you would do this in a line of C-code [4 marks]

(iv) An LPC1114 microcontroller requires bits 1,4 and 9 of General Purpose IO Port 0 to be outputs, all other bits to be inputs. Show how you would program this in C. [4 marks]

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

(b) Listing Q2b contains 2 functions that are used for serial data communications on the LPC1114 microcontroller

(i) Illustrate the operation of the functions by explaining the sequence of events that occurs when the following function call is executed:

printString("ABC"); [6 marks]

(iii) Write a C-function that converts an unsigned 32 bit number to a hexadecimal string and then sends this string to the printString function. [7 marks]

Listing Q2b

```
void eputc(char c)
{
     U0THR = c;
     while((U0LSR & BIT5) == 0); // Wait for tx to finish
}
void printString(char *String)
{
     while(*String)
     {
          eputc(*String);
          String++;
     }
}
```

Question 3:

(a)

The contents of some of the LPC1114 core registers are as shown below. Also shown are the contents of some memory locations. What number goes where when each of the following instructions is executed one after another in a program?

PUSH R0 [3 marks]

POP R1 [3 marks]

BX LR [3 marks]

Contents of Registers

Register	Contents
R0	0x10a987fe
R1	0xa940221a
PC	0x000010a3
SP	0x20000804
LR	0x00001902

Contents of RAM

Address	Contents
0x200007fc	0x00000001
0x20000800	0x00000002
0x20000804	0x00000003
0x20000808	0x00000004
0x2000080c	0x00000005

(b) Describe the interrupt handling process in the LPC1114 microcontroller. [5 marks]

(c) Listing Q3a shows an ARM Thumb assembler listing for a **strcpy** function

(i) What happens when Lines A, B and C are executed [9 marks]

(ii) How would you modify this program so that it implements the safer alternative:

```
int strncpy(char *dst, char *src, int len)
```

where **len** is the maximum length of the destination string? [10 marks]

Listing Q3a

```
; int strcpy(char *dst, char *src)
; This function takes two arguments:
; a source string (src) and a destination
; string (dst).  The function copies the
; contents of src to dst.  All bytes
; up to and including the terminating
; null (hopefully present) will be copied
; On entry R1 points to the destination string
; R2 points to the source string.  On
; exit R0 contains a count of the bytes copied
strcpy
     push {LR,R1-R3}      ------------------------------>LINE A

     movs R0,#0           ; zero the count
     movs R3,#0           ; clear out R3
strcpy_loop
     ldrb R3,[R2]         ; read byte
     strb R3,[R1]         ; write byte
     adds R0,R0,#1        ; increment count
     adds R1,#1           ; increment dst
     adds R2,#1           ; increment src
     cmp R3,#0            ; at the end
     beq strcpy_exit      ; if so, exit ---------------->LINE B
     b strcpy_loop        ; else go back
strcpy_exit
     pop {PC,R1-R3}       ------------------------------>LINE C
```

Question 4:

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

(ii) LR [2 marks]

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

(i) 9-9 [2 marks]

(ii) 0xfffffffe+4 [2 marks]

(iii) 1-2 [2 marks]

(iv) 0x7fffffff+2 [2 marks]

(c) Using suitable examples, explain the use of the following ARM Thumb assembler directives:
(i) SPACE [2 marks]
(ii) DCD [2 marks]
(iii) AREA [2 marks]

(d) The ARM Architecture Procedure Call Standard (AAPCS) describes the way parameters are passed to functions and how the function return results to the caller.
(i) According to the AAPCS how should a single integer parameter be passed to a function? [4 marks]
(ii) According to the AAPCS by what mechanism should a function return a 64 bit result? [4 marks]
(e) The LPC1114 is a 32 bit processor. Using suitable assembly language code show how you can add two 64 bit numbers on this processor [7 marks]