University of Texas at Austin
Electrical and Computer Engineering Department

EE319K, Embedded Systems, Spring 2013
Final Exam

Directions There are 6 problems worth a total of 100 points. The number of points for each question is indicated. Make sure that you show all work since partial credit will be given. This exam is closed book, closed notes, and **no calculators are allowed**. You may not communicate in any way with anyone other than exam proctors during the exam time. Don't forget to put your name down on the first page.

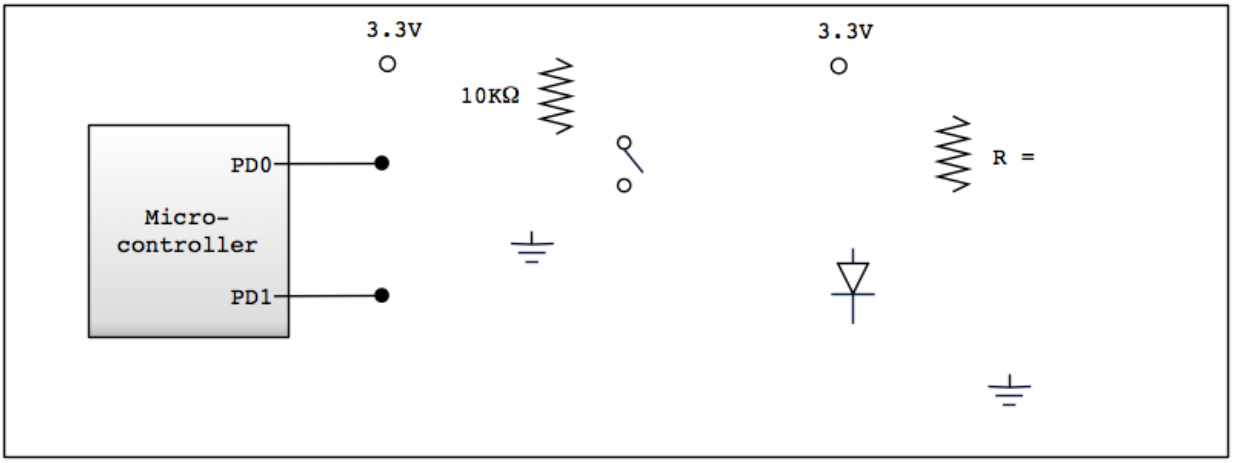
You have **3 hours** to finish the exam

Name: _____

	Points possible	Score
Problem 1	15	
Problem 2	15	
Problem 3	20	
Problem 4	15	
Problem 5	20	
Problem 6	15	
Total	100	

1. (15 points) Appropriately Interface a switch and an LED to pins PA0 and PA1 respectively so when the following code snippet is run the relationship between the switch and LED is a NOT logic. That is when the switch is on the LED is off and vice-versa. The LED's operating point is $V_d = 1.6V, I_d = 1mA$. You may or may not need all the circuit elements provided.

```
#define PA0 (*((volatile unsigned long *)0x40004004))
#define PA1 (*((volatile unsigned long *)0x40004008))
int main() {
   ... // Port A pin 0 is input and pin 1 is output
   while (1) {
       PA1 = PA0; // write switch logic state to LED
    }
 }
```



(a) What is the value of resistance R used to interface the LED?

(b) What interface logic does did you use to connect the switch to the microcontroller?

(c) What interface logic does did you use to connect the LED to the microcontroller?

2. (15 points) There are two parts to this question. First, complete the C subroutine below that takes a string of characters that are null terminated and returns the checksum of these characters. The checksum of a list of characters is defined as the bit-wise Exclusive-Or of all the characters together.
Hint: To perform the XOR of multiple characters you can do a bit-wise XOR of the first two characters and then perform a bit-wise XOR of the result with the third character and so on.

```
unsigned char ChkSum(unsigned char *array) {
// Note:  In C, arrays are implemented using pointers where an array is just a
// pointer to the first element.  array[i] access the i'th element of the array









}
```

For the second part, you are required to write assembly code that calls (call-by-reference) the above C subroutine from assembly. Include appropriate `IMPORT` and/or `EXPORT` statements and follow the AAPCS calling convention.

```
input SPACE  60 ; Storage for a null-terminated char array

; Assume input is initialized here and null terminated (you don't have to do)

; Setup call to ChkSum by passing it the appropriate information (call-by-reference)




JSR ChkSum
```

---

3. (20 points) In the following code, the stack is used for passing an input parameter, a return value, local variables, and, to save registers that the subroutine modifies. The subroutine makes use of two local variables, which are accessed using the stack pointer (SP) as the frame pointer. Read the comments to understand the code and pay attention to instructions to figure out the sizes of input/output parameters and variables. Note, the code below does not use AAPCS convention.

```
AREA       DATA ; Memory address 0x2000.0000
Result  SPACE  4
AREA       |.text|, CODE, READONLY, ALIGN=2  ; Memory address 0x0000.0100
Count       DCW  10
main
      LDR   R0,=Count
      LDRH  R1,[R0]
      STRH  R1,[SP],#-2      ; Pass input on stack and post-decrement SP by 2
      SUB   SP, #4           ; Allocate space for return value on stack
      JSR   Sub
      LDR   R1, [SP, #nnn]   ; get return value into reg R1
      LDR   R0,=Result
      STR   R1, [R0]         ; put returned value into global variable Result
      ADD   SP, #6           ; De-Allocate input and output space
lp    B     lp               ; Loop indefinitely

     ;****************Sub*************
inp  EQU   aaa               ; binding for input parameter
out  EQU   bbb               ; binding for return value
sum  EQU   ccc               ; binding for local variable sum
num  EQU   ddd               ; binding for local variable num
Sub
      PUSH  {R0,R1}   ;  save registers
      SUB   SP, #6           ;  Allocate space for sum and num
      LDRH  R0, [SP, #inp]   ; get a copy of input parameter into R0
      STRH  R0, [SP, #num]   ; set local variable num to passed input
      MUL   R1, R0, R0
      STR   R1, [SP, #sum]   ; change sum
      LDR   R0, [SP, #sum]
--->  STR   R0, [SP, #out]   ; store sum into out to return
      ADD   SP, #6           ; De-allocate locals
      POP   {R0,R1}   ; restore registers
      BX    LR
      ALIGN
      END
```

(a) (10 points) What are the values of aaa, bbb, ccc, ddd and nnn?

aaa	
bbb	
ccc	
ddd	
nnn	

(b) (10 points) Give the contents of the stack *after* line indicated by the arrow `--->` is executed, along with where the Stack pointer (SP) points to. The stack state immediately preceding the subroutine call is shown.
Notes: (i) Each entry in the table is 2-bytes, (ii) you may or may not need all the locations in the table, (iii) if a variable is 4 bytes then fill its value in multiple locations

SP− >		out
	10	inp

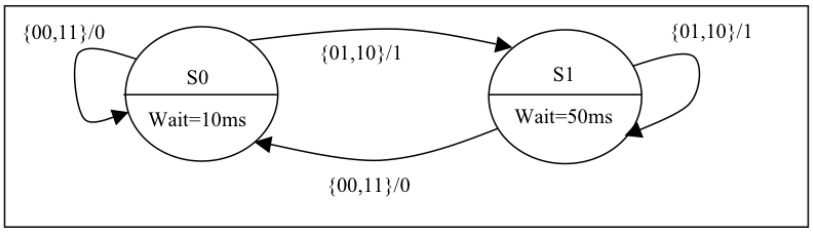
4. (15 points) Answer the following

(a) (5 points) Given two boards communicating using UART0 with a baud-rate set to 40 Kbps (kilo bits per sec). Assuming the one start bit and one stop bit are used per byte, how much time will it take to transmit a text file of size 10Mbytes?

(b) (5 points) Assuming the Bus cycle speed of 50MHz, what values must the registers `UART0_IBRD_R` and `UART0_FBRD_R` be set to for a baud-rate of 40 Kbps?

(c) (5 points) Assuming the Bus cycle speed of 50MHz, what should the register `NVIC_ST_RELOAD_R` be set to for the Systick interrupt to occur every 100ms?

5. (20 points) Given the following Mealy FSM:



Part a(10 points): Fill the blanks in the C code below that implements the FSM:

```
#define PA0 (*((volatile unsigned long *)0x40004004))
#define PA21 (*((volatile unsigned long *)0x40004018))
const struct State{
      ________________Out[4];                    // Output to PA0
      unsigned short wait;                     // Wait time
      const struct State _________________;  // Next states
};
typedef const struct State StateType;
typedef StateType * StatePtr;
#define S0 ______________

#define S1 ______________
fsm[_______] = {

    { ___________________________________________},  // S0 Transition table

    {___________________________________________}   // S1 Transition table
};

_____________________Pt;  // Pointer to Current State
```

Part b (10 points): Assuming that the two bit input comes from pins PA1 and PA2 and the following Delay routine is given for you to call:
`void Delay(unsigned short); // Input is millisecs to wait`
Complete the following FSM controller routine (`delay->input->output->state_change`):

```
void FSMController() {
      while(1) {









      }
}
```

6. (15 points) Answer the following

   (a) (4 points) What is the purpose of the `E` pin in the HD44780 protocol for the LCD interface? What changes does one have to make to it when writing a character to the LCD?

   (b) (4 points) In Lab8 where we had the background thread writing to the global variable `ADCMail` and the main program reading `ADCMail`. Why did this not cause a race condition?

   (c) (4 points) If the input voltage is 1.0V, what value will the LM3S 10-bit ADC return?

   (d) (2 points) If we want 25 unique levels from an n-bit DAC, what is the minimum n that can accompish this?

   (e) (1 point) We enable the ADC clock by setting bit 16 of the `SYSCTL_RCGC0_R` register. [True/False]