Department of Electrical and Computing Engineering

UNIVERSITY OF CONNECTICUT

ECE 3411 Microprocessor Application Lab: Fall 2015

Lab Test IV

There is 1 long programming problem in this test. There are 3 pages in this booklet. Answer each question according to the instructions given.

You have **100 minutes** to answer the questions. Once you are done, you need to show the output to the Instructor or TA and e-mail the code to the TA.

Some questions are harder than others and some questions earn more points than others—you may want to skim all questions before starting.

If you find a question ambiguous, be sure to write down any assumptions you make.
Be neat and legible. If we can't understand your answer, we can't give you credit!

Write your name in the space below. Write your initials at the bottom of each page.

THIS IS AN OPEN BOOK, OPEN NOTES TEST.
YOU CAN USE YOUR LAPTOP BUT PLEASE TURN YOUR NETWORK DEVICES OFF.

Any form of communication with other students is considered cheating and will merit an F as final grade in the course.

Do not write in the boxes below

1(a) (x/20)	1(b) (x/30)	1(c) (x/30)	1(d) (x/20)	Total (xx/100)

Name:

Student ID:

1. **[100 points]:** In this task, we are going to design a Stopwatch (1ms resolution) for measuring the total time and the individual lap times of a car racer. A detailed breakdown of the task is given below, whereas the detailed timing diagram of the stopwatch is shown in Figure 1.

Notice that for this task, `_delay_ms()`/`_delay_us()` function calls are not allowed (except for the ones already present in `lcd_lib.c`).

a. (20 points) Using ***Pin Change Interrupts***, read two push switches SW1 and SW1 connected to PB1 and PB7 respectively, and design a basic system that does the following:

- When SW1 is pressed, LED1 turns on. This shows the start of the race.
- While LED1 is on, if SW2 is pressed then LED2 toggles. This shows completion of a lap.
- Finally if SW1 is pressed again, both LEDs turn off. This shows end of the race.

Use `Timer0` to count a debounce delay of 16ms for SW1 and SW2.

b. (30 points) Extend Task(a) and use `Timer1` to implement the following basic stopwatch:

- When SW1 is pressed (i.e. start of the race), start `Timer1` to count the number of milliseconds. You may want to use a software counter to keep track of long time intervals.
- When SW1 is pressed again (i.e. end of the race), record the current time. This shows end of the race.
- Print the total elapsed time (in milliseconds) on the first row of the LCD.

Make sure that you debounce SW1 with a 16ms delay using `Timer0`, yet start/capture `Timer1` at the very moment of the button push (as shown in Figure 1) instead of 16ms later.
Hint: You can read the current value of Timer1 by reading `TCNT1` register anywhere in the code.

c. (30 points) Extend Task(b) to implement the following functionality of the stopwatch:

- If SW2 is pressed while the stopwatch is counting (i.e. during the race), record the current time. This shows completion of a lap. Notice that `Timer1` continues to count the total race time.
- Print on the second row of the LCD the time elapsed (in milliseconds) between this SW2 push and the previous most recent button push event. This shows the lap time of the racer. E.g. if SW2 is pressed for the first time after the start of the race then print the total time elapsed since SW1 push. Otherwise print the time elapsed since last SW2 push (as shown in Figure 1).

Make sure that you debounce SW2 with a 16ms delay using `Timer0`, yet capture `Timer1` at the very moment of the button push (as shown in Figure 1) instead of 16ms later.

d. (20 points) Extend Task(c) to complete the stopwatch implementation as follows:

- Finally when SW1 is pressed again (i.e. at the end of the race), record the final lap time which is the time since the last SW2 push (as shown in Figure 1).
- Print the total race time on first row and the best lap time (i.e. the smallest) among all the recorded lap times on the second row of the LCD.

Hint: Determine and record the smallest lap time at each SW2 push.
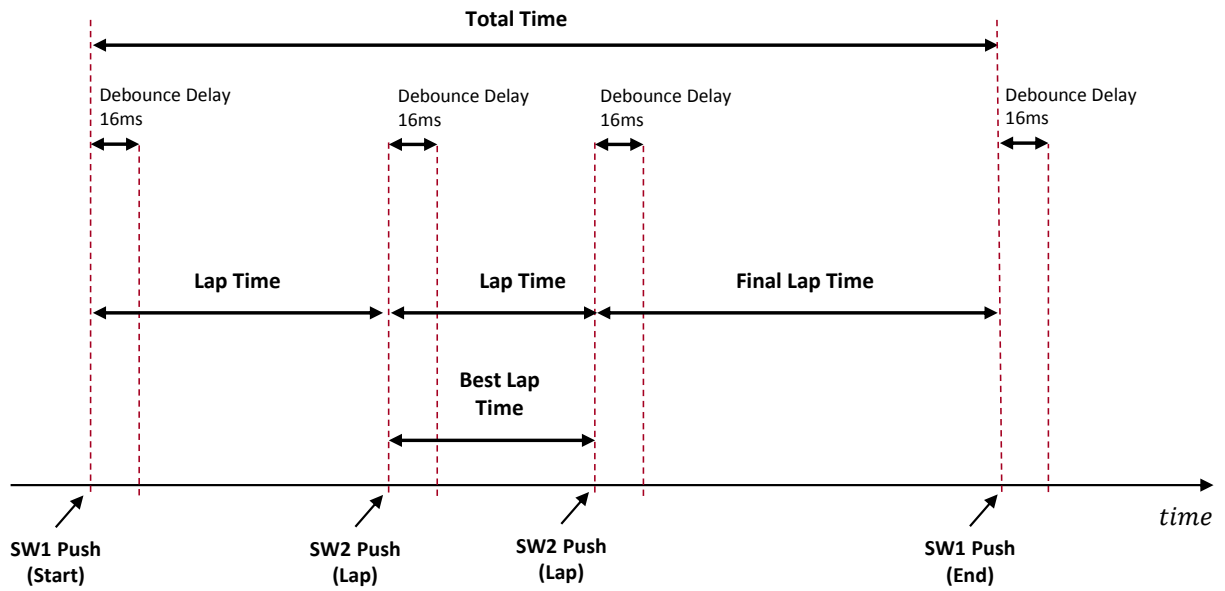
Initials:

Figure 1: Stopwatch Timing Diagram.

End of Quiz

Please double check that you wrote your name on the front of the quiz.

Initials: