Midterm Exam 2

- Fill in your name:
- This exam is open book and open notes.
- The exam is 80 minutes and worth 100 points.
- Show all your work.

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
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<tbody>
<tr>
<td>1</td>
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1. **Semaphores** (25 points)

   The spin-lock semaphore implementation in Program 5.8 on page 276 requires interrupts to be temporarily disabled while the semaphore $S$ is being read and modified. Assume the existence of a new test-and-set instruction, `tset`. Using this instruction and a new `lock` variable, we can test that the lock is 0 and set it to 1 in one atomic operation. If the test finds that the lock is already 1, then it will clear the carry bit in the condition code register to indicate a failure. Otherwise, the carry bit will be set to 1. This new instruction allows us to implement `wait` and `signal` without disabling interrupts as follows:

   ```
   S fcb 1
   lock fcb 0
   wait tset lock sets carry to 1 if lock is successfully set to 1
       bcc wait
   loop ldaa S
       bhi OK
       bra loop
   OK deca
       staa S
       clr lock
       rts
   signal tset lock
       bcc signal
       inc S
       clr lock
       rts
   ```

   (a) The code above, unfortunately, can result in a deadlock. Give a detailed example demonstrating how deadlock can occur.

   (b) This problem can be eliminated by making a small modification to the code above. Show the modification on the above code.
2. **Input Capture, Output Compare, and Serial I/O** (50 points)

In this problem, you will use input capture and output compare to construct an SCI interface. A block diagram for this interface is shown below. Assume a baud rate of 1000 bits/s. Your interface should provide both transmit and receive functionality. You can assume the existence of the subroutines InitFifo, PutFifo, and GetFifo. InitFifo has no parameters and you can assume that it will save and restore any registers that it uses. PutFifo puts the 8-bit data in RegA into the FIFO. GetFifo takes a pointer in RegX to the place to put the 8-bit data taken from the FIFO. The main program (which you do not need to provide) will extract ASCII characters from the RxFIFO, and it will put ASCII characters into the TxFIFO. In the case of transmission, you can assume that it will arm an output compare interrupt handler to start the transmission.

(a) Draw the output signal when the ASCII character 'A' (41 in hex) is transmitted. Assume that TCNT is 2000 (decimal) at the start of transmission. Give the TCNT value for each transition of the output signal. Place arrows on the drawing to indicate where the IC and OC interrupts will occur, giving the TCNT value at each interrupt. Do the same thing for when an 'A' is received.

(b) Define all needed global variables.

(c) Show the ritual that initializes the global variables, input capture, and output compare interrupts.

(d) Show the input capture and output compare interrupt handlers.
Extra page for problem 2
Extra page for problem 2
3. **Input Switches** (5 points)
   You want to debounce a switch with a capacitor. Assume a bounce time of 3 ms and that you are using a 2 KΩ pullup resistor. Be sure to show all calculations.

   (a) What capacitance value should it have?

   (b) Due to this capacitor, how long will the signal spend in the transition region (0.7v to 2v) when it is rising?
4. **Output LEDs** (20 points)

You would like to construct a bright 2 character LED display. To make it bright, assume a desired current of 20mA through the LED. You may use any figures or tables from Chapter 8 necessary to answer the following questions. Assume characteristics for RED LEDs apply.

(a) Draw a schematic for the display. Label all parts including values for resistances (show calculation).

(b) What are the maximum number of digits that you can extend this display to? Why? What would the maximum peak forward current and maximum power be for this larger display? How much time would be available to display a single digit?