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>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>
1. **Semaphores** (20 points)
   Consider this code for a spin-lock counting semaphore when answering the following questions.

   ```
   1:S   fcb 1
   2:wait sei
   3:   ldaa S
   4:   bhi OK
   5:   cli
   6:   bra wait
   7:OK  deca
   8:   staa S
   9:   cli
   10:  rts
   ```

   (a) Why must interrupts be disabled on line 2?

   (b) Why must interrupts be reenabled on line 5?

   (c) Microprocessors often include explicit test-and-set instructions for semaphores. Why are these instructions useful?
2. **Motor Interface** (20 points)

This problem considers the hardware interface between an output port of a microcontroller to control a DC motor. The computer activates the motor by driving a current through the motor (drawn as an inductor). It deactivates it by not providing it a current. Assume the coil of the motor has a resistance of $133\,\Omega$ and an inductance of $40\,\mu\text{H}$. Also, assume that the solenoid activates when the coil voltage is above $4\,\text{V}$ (i.e., a coil current of about $30\,\text{mA}$). Assume that your driver has a speed of $15\,\text{ns}$ to go from low to hiZ and $2\,\mu\text{s}$ to go from hiZ to low.

(a) Calculate the back EMF caused by deactivating your driver. (Hint: this voltage is caused by a change in current through an inductor).

(b) Calculate the back EMF caused by activating your driver.

(c) Draw a schematic of your hardware interface. Be sure to label with part numbers. Use the tables in Chapter 8 to select the parts to use.
3. **Input Capture, Output Compare, and Serial I/O (60 points)**

In this problem, you will use input capture and output compare to construct an SPI interface. DO NOT USE THE SPI INTERFACE PROVIDED IN THE 68HC11 MICROCONTROLLER. Instead construct one using PortC and software. A block diagram for this interface is shown below. Assume a transfer frequency of 62.5 kHz. You will be writing software for both the master and the slave. When the master wishes to send or receive data, the main program will write a value into the global variable SPIDATA and call a ritual to begin the communication. The slave should only act upon edges of the SCK.

(a) Will the master use input capture or output compare? How about the slave?
(b) Write the ritual called by the main program to initiate a transfer.
(c) Write the interrupt handler for the master.
(d) Write the ritual and the interrupt handler for the slave.