THE UNIVERSITY OF BRITISH COLUMBIA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
APSC 380 : Introduction to Microcomputers
1998/99 Winter Session Term 2

FINAL EXAMINATION
8:30 – 11:30 A.M.
April 20, 1999

This exam has five (5) questions on four (4) pages. The marks for each question are as indicated. There are a total of forty-three (43) marks. Answer all questions. Write your answers in the exam book provided. Show your work. You may answer the questions in any order. Books, notes and calculators are allowed. You may keep this exam paper.

Question 1 (8 marks)

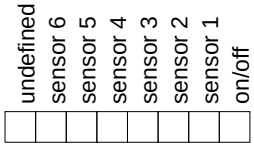
What is printed by the following C program?

```
#include <stdio.h>

int pow2 ( int x )
{
   int n ;
   n = 1 ;
   while ( x > 0 ) {
      n = 2 * n ;
      x = x - 1 ;
   }
   return n ;
}

void main(void)
{
   int i, c ;
   char x[] = { 1, 2, 3, 4, 0 } ;

   for ( i=0 ; x[i] ; i++ ) {
      if ( x[i] ) {
         printf ( "%d\n", pow2(x[i]) ) ;
      }
   }
}
```

Hints: Figure out what values are passed to the `pow2()` *function. Figure out the purpose of the* `pow2` *function.*

Question 2 (7 marks)

This question asks you to write a C program that implements a simple alarm system. The alarm has 6 sensors and one control switch. The state of each of the sensors and the switch can be obtained by reading a byte from memory location 200 (hex). The least significant bit of this byte has the value 1 if the alarm is on, and 0 if it is off. Each of the next six bits has the value 1 if a sensor is active and 0 if it is inactive. The value of the most significant bit is undefined:

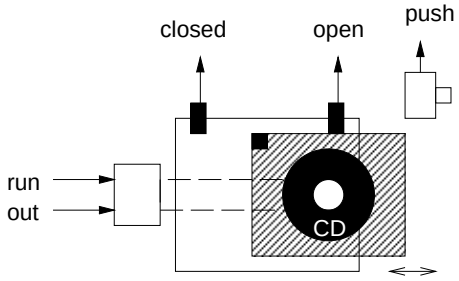


Your program should continuously monitor the state of the switch. If the switch is on and one or more of the six sensors are active then an alarm should be sounded by writing the value 0x01 to memory location 200 (hex) otherwise the alarm should be turned off by writing the value 0 to 200 (hex).

Use the `speek()` and `spoke()` functions as used in the labs to read and write the memory locations. You need not include comments.

Question 3 (10 marks)

This question asks you to design a controller to control the motor that slides the CD tray in and out of a CD player. The inputs and outputs are as shown below:



The controller has one push-button input, `push` and two limit switches `in` and `out` that indicate that the tray is fully in or fully out of the player respectively. Your controller has two outputs: `run` which makes the motor run to move the tray in or out and `out` which determines the direction that the tray moves (out when `out` is asserted).

If the tray is fully in or fully out, the controller ignores all inputs except the push button. Pushing the button actuates the motor to start moving the tray out or in (respectively) until it reaches the opposite limit. While the tray is moving it ignores all inputs except the one expected limit switch. You can ignore unusual conditions such as might be caused by sensor failures or if the tray is left partly out.

Design a state machine for the controller. List the inputs and outputs. Choose a sufficient number of states and give a name to each state. Write a table giving the output for each state. Draw a state transition diagram showing the states and the logical conditions that cause transitions between them. Write out a tabular description of the state machine with the following columns: starting state, input, next state.

You may use an "X" to indicate that an *input* has no effect.

Hint: My solution has 4 states.

Question 4 (4 marks)

A 3-input majority-voter is a circuit that combines three redundant inputs into one output. The output is set to 1 if two or more of the inputs are 1, otherwise it is set to zero as shown in the following truth table:

inputs			output
A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Derive the boolean logic equation for the output. Draw a schematic diagram for the majority voter using AND, OR and NOT gates. You need not simplify your solution.

Question 5 (14 marks)

(a) For each electric motor requirement in column "A" select the best matching entry in column "B". Write your answers in numerical order and show the number and the selected letter unambiguously.

A		B	
1	variable speed	A	servo motor
2	no brushes or commutator	B	stepper motor
3	accurate shaft position	C	induction motor
4	fixed shaft angle increments	D	DC motor

(b) For each electronic component listed in column "A" select the best matching description in column "B". Write your answers in numerical order and show the number and the selected letter unambiguously.

A		B	
1	phototransistor	A	differential amplifier
2	LED	B	provides electrical isolation
3	optocoupler	C	generates light
4	op-amp	D	controlled by light
5	full-wave rectifier	D	conducts in either direction
6	diac	D	uses four diodes

(c) An electric motor is running at 3600 rpm and is providing $\frac{1}{4}$-horsepower. What is the torque on the shaft?

(d) What A/D converter resolution is required to measure a voltage of between 0 and 3 volts with an accuracy of 1 millivolt?