THE UNIVERSITY OF BRITISH COLUMBIA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
APSC 380 : Introduction to Microcomputers
1997/98 Winter Session Term 2

FINAL EXAMINATION
3:30 am – 6:30 P.M.
April 24, 1998

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 (6 marks)

What is printed by the following C program?

```
#include <stdio.h>
#define N 5

int even(int i)
{
   return ( i & 1 ) == 0 ;
}

int next(int i)
{
   return i + 1 ;
}

void main(void)
{
   int i, c ;
   char x[N] ={ 'a', 'b', 'c', 'd', 'e' } ; /* values of x[0], x[1], ... */
   for ( i=0 ; i<N ; i++ ) {
      if ( even(i) ) {
         c =  next( x[i] ) ;
         printf ( "%d\n", c ) ;
      }
   }
}
```

Hints: Figure out the values taken on by `i`*. The ASCII value for* `a` *is 97 (decimal). The ASCII values for letters are assigned in ascending alphabetical order (e.g.* `b` *is 98,* `c` *is 99, etc).*

Question 2 (7 marks)

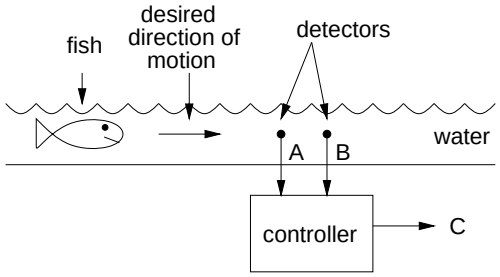
Write a C function declared as `int oesum(int a[], int n, int doeven)`. The argument `a` is an integer array and `n` is the number of elements in the array. If the argument `doeven` is non-zero, your function should return the sum of the even-valued numbers in the array, otherwise your function should return the sum of the odd-valued numbers in the array. Write only the function `oesum()`, not a complete program.

For example, if `a` contained the values `{2, 1, 3}`, then `oesum(a,3,2)` would return 2 and `oesum(a,3,0)` would return 4.

Hint: Make sure any logical expressions do what you expect.

Question 3 (12 marks)

This question asks you to design a controller that generates an output pulse when a fish is detected swimming in the desired direction down a stream. Your controller has two fish-detector inputs: `A` and `B` and one indicator output: `C` as shown below:



The fish detector outputs are 0 (no fish detected) and 1 (fish detected). The controller output is initially set to 0 while waiting for a fish. To make sure you only detect fish swimming in the desired direction, your controller must wait until A is 1 and B is 0 followed by the situation when A and B are both 1. When this sequence of input conditions occurs the output C is turned to 1. C remains set to 1 until A turns to 0 again. The controller then resumes waiting for a fish.

Fish swimming the wrong way (from B to A) or that only manage to turn A to 1 and then exit backwards should not generate an output pulse. Fish that are so fast that they only turn A to 1 and then only B to 1 should also not generate an output. However, once a fish has turned on only A and then both A and B you may assume it will continue swimming in the desired direction.

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 3 states.

Question 4 (4 marks)

A 3-input even parity generator is a combinational circuit with three inputs and one output. The output is high (1) if the input contains an even number of '1's as shown in the following truth table:

inputs			output
A	B	C	P
0	0	0	1
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	0

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

Question 5 (14 marks)

(a) For each type of electric motor 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	stepper	A	fixed speed
2	servo	B	A.C. powered
3	induction	C	uses feedback
4	synchronous	D	all-digital control

(b) For each type of A/D converter 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	flash	A	inexpensive
2	successive approximation	B	slow
3	dual-slope	C	fast
4	voltage-frequency	D	N steps for N bits

(c) What is the value of the following 'C' expression? Give your answer in hexadecimal and show your work.

```
(21 ^ 0x31) >> 1
```

(d) A microprocessor has a built-in 8-bit A/D converter that converts an input between 0 and 5 volts to a value between 0 and 255. What is the A/D converter's resolution?

(e) A MOSFET power transistor with a maximum $R_{\mathrm{DS_{on}}}$ of 25 mΩ is used to switch a current of 20 A. The manufacturer specifies a maximum junction temperature of 200 C and a junction-to-heatsink thermal resistance of 4 degrees/W. The device must operate up to an ambient temperature of 80 C. How should you specify the heat sink? Show your work.