THE UNIVERSITY OF BRITISH COLUMBIA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
APSC 380 : Introduction to Microcomputers
1997/98 Winter Session Term 1

FINAL EXAMINATION
3:30 PM – 6:30 PM
December 5, 1997

This exam has five (5) questions on four (4) pages. The marks for each question are as indicated. There are a total of 60 marks. Answer all questions. Write your answers in the exam book provided. Show your work. You may answer the questions in any order. Use K&R indentation and symbolic constants where appropriate. Comments are optional. Books, notes and calculators are allowed. You may keep this exam paper.

Question 1 (12 marks)

What is printed by the following C program?

```
#include <stdio.h>
main()
{
   int i=0 ;
   while ( i < 32 ) {
      printf ("%d\n", i ) ;
      if ( i & 0x02 ) {
         i = 2 * i  ;
      } else {
         i = i | 3 ;
      }
   }
}
```

Hints: Work carefully. Show your work. The program does terminate.

Question 2 (10 marks)

This question asks you to write a C function to compute the total area of all of the useful pieces of wood in a lumberyard. Your function, `area()`, will be passed three arguments. The first two arguments are integer arrays, `w` and `l`, containing the widths and lengths of every piece of wood (in cm). The third argument, `n`, is an integer giving the number of pieces of wood. You function must return an integer value which is the total area (in cm^2) of all of the usable pieces of wood. A piece of wood is defined to be usable if both the width and the length are greater than or equal to 5 cm. Write only the `area()` function, not a `main()` program.

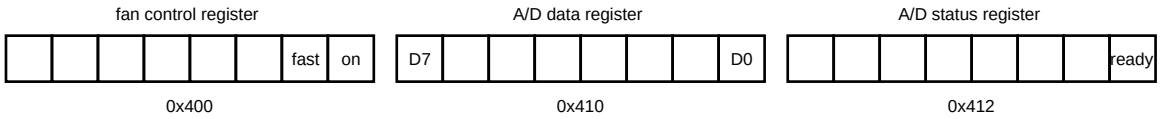
Hint: the area of a piece of wood is the product of its width and length.

Question 3 (12 marks)

This question asks you to write a C program to control a two-speed cooling fan. The fan speed should be set according to the temperature, T, as follows:

Temperature (T)	Fan Speed
$T < 25$	off
$25 \leq T \leq 40$	slow
> 40	fast

Your program has access to three registers as shown below:



Your program controls the fan by writing to a control register at address 0x400. The least-significant (LS) bit controls the motor (1=on, 0=off). The second least-significant bit controls the speed (1=fast, 0=slow). The other bits of the control register have no effect.

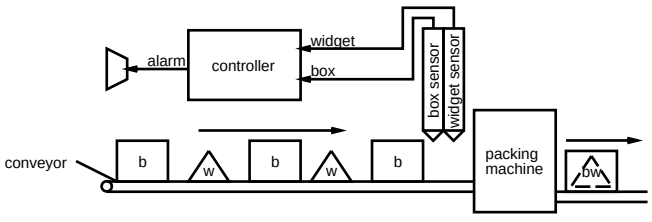
Your program determines the temperature by reading an (8-bit) A/D data register at address 0x410. The value read from this data register is related to the temperature by the equation $value = 4T + 25$.

The A/D has a status register at address 0x412. The LS bit of this status register indicates whether the A/D data register is ready to be read (1=ready, 0=not ready). The values of the other bits of the status register are undefined. Your program must wait until the status register indicates that the A/D data register is ready to be read before reading the A/D data register.

Write a C program (a `main()` function) that continuously monitors the temperature and adjusts the fan speed according to the specifications given above. Use the `speek()` and `spoke()` functions described in Lab 2 to read and write the registers.

Question 4 (12 marks)

A widget-packing machine (shown below) alternately receives boxes and widgets from a conveyor belt. The machine uses each pair to produce a boxed widget.



This question asks you to design a state machine for a controller that turns on an alarm when an out-of-order item arrives at the packing machine. You do *not* need to include a feature to turn off the alarm.

The controller has two inputs: a box-sensor (`box`), and a widget-sensor (`widget`). Each input is 1 when the corresponding item arrives at the machine. Only one of the inputs can be 1 at any given time. Between items both sensors are 0. The controller has one output (`alarm`) that rings the alarm when it is set to 1.

Design a state machine for the alarm 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 condition 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, inputs, next state. You need not include input conditions that are not possible.

Question 5 (14 marks)

For parts (a) and (b) explain your reasoning in one or two sentences. Your answers must be unambiguous.

(a) [Multiple Choice] The STROBE signal of a parallel printer interface should be set low when:

- **(a)** the BUSY signal is high
- **(b)** the BUSY signal is low
- **(c)** the data lines contain the next character to print
- **(d)** (a) and (c)
- **(e)** (b) and (c)
- **(f)** none of the above

(b) [Multiple Choice] You need to A/D convert a slowly-changing analog signal generated by a remote sensor. The sensor is connected to the A/D by a long pair of wires running through an industrial plant with many electrical machines. You notice that the signal at the input to the A/D converter is very noisy. Which of the following devices might help you resolve this problem:

- **(a)** a multiplexer
- **(b)** a low-pass filter
- **(c)** a sample-and-hold
- **(d)** a differential amplifier
- **(e)** (b) and (d)
- **(f)** (c) and (d)
- **(g)** (a) and (c)
- **(h)** none of the above

(c) You want to use an A/D converter to measure the voltage obtained from a linear pressure sensor. The pressures to be measured range from 1 to 10 atm. The measurement needs to be accurate to 0.3 atm. The A/D range covers the full range of the sensor output voltage. What is the minimum number of bits of resolution required for the A/D? Show your calculations.

(d) What is the minimum number of pins required by an 8 kilobyte (kB) byte-wide RAM chip? Show how you arrived at your answer.

(e) Draw the waveform that appears on the TxD (Transmit Data) line when a DTE sends the ASCII character `'E'` at 9600 bps with 7 data bits and no parity. Label the time and voltage axis. Indicate the approximate duration of each bit and choose valid RS-232 signal levels.