

國立臺灣科技大學102學年度碩士班招生試題

系所組別：資訊工程系碩士班

科目：資訊工程概論

(總分為100分)

1. In most modern operating systems, a thread is a basic unit of CPU utilization and a process may contain multiple threads.

(a) The four major benefits that may be obtained from multithreaded programming are "Responsiveness", "Resource sharing", "Economy", and "Scalability". Nevertheless, when the threads are created in the user space (i.e. user-level threads), some of the benefits will not be obtainable. Which of the four benefits cannot be obtained? Why? (5%)

(b) Which of the variables, x , y , z , r , and s , declared in the program segment of Fig. OS_1, are sharable among the threads started from the function, $funThrd()$? (5%)

```
int x;
static int y;

int funThrd(int z)
{
    int r;
    static int s;
    ...
}
```

Fig. OS_1

2. A solution to the critical-section problem must satisfy the three requirements: mutual exclusion, progress, and bounded waiting. The program segment in Fig. OS_2 is designed with the hardware instruction, $swap()$, and is tried to solve the critical-section problem.

(a) Can the requirement "mutual exclusion" be satisfied? If not, what is the bug that must be fixed? (5%)

(b) Suppose that "mutual exclusion" is satisfied either by fixing some bugs or by no need. Can the requirements, "progress" and "bounded waiting" be satisfied? (5%)

```
do {
    key = TRUE;
    while (lock == TRUE)
        swap(&key, &lock);
    // critical section
    lock = FALSE;
    // remainder section
} while (TRUE);
```

Fig. OS_2

3. The basic algorithms for CPU scheduling include *First Come First Serve*, *Shortest Job First*, *Priority Scheduling*, and *Round Robin*. In addition, two more complicated scheduling algorithms are *Multi-Level Queues* and *Multi-Level Feedback Queues*.

(a) Among the six scheduling algorithms, which is able to distinguish between I/O-bound and CPU-bound processes? (4%)

(b) Which basic scheduling algorithm should we select if the average response time of a process is the major concern? (3%)

(c) Which basic scheduling algorithm may encounter the problem that a process is indefinitely blocked? (3%)



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4. A compiler designer is trying to decide between two code sequences for a particular computer. The hardware designers have supplied the following facts:

	CPI for instruction class		
	A	B	C
CPI	3	4	2

For a particular high-level-language statement, the compiler writer is considering two code sequences that require the following instruction counts:

Code sequence	Instruction counts for instruction class		
	A	B	C
1	2	2	6
2	2	5	1

- (a) Which code sequence executes the most instructions? (2%)
 (b) Which will be faster? (2%)
 (c) What is the CPI for each sequence? (2%)

Suppose we measure the code for the same program from two different compilers and obtain the following data:

Code form	Instruction counts(in billions) for instruction class		
	A	B	C
Compiler 1	1	2	7
Compiler 2	2	1	5

Assume that the computer's clock rate is 5 GHz.

- (d) Which code sequence will execute faster according to execution time? (2%)
 (e) Which code sequence will execute faster according to MIPS? (2%)
5. Consider three different cache configurations below:
 Cache 1: direct-mapped with four-word blocks.
 Cache 2: two-way set associative with two-word blocks and LRU replacement.
 Cache 3: fully associative with four-word blocks and LRU replacement.

Assuming that each cache has total data size of 16 32-bit words and all of them are initially empty. 20-bit word address is used. Consider the following sequence of address references given as word addresses: 20, 23, 33, 34, 28, 35, 45, 47, 56, 57 and 20. For caches 1, 2, and 3, please label each reference in the list as a hit or a miss. (3%, 4%, 3%)



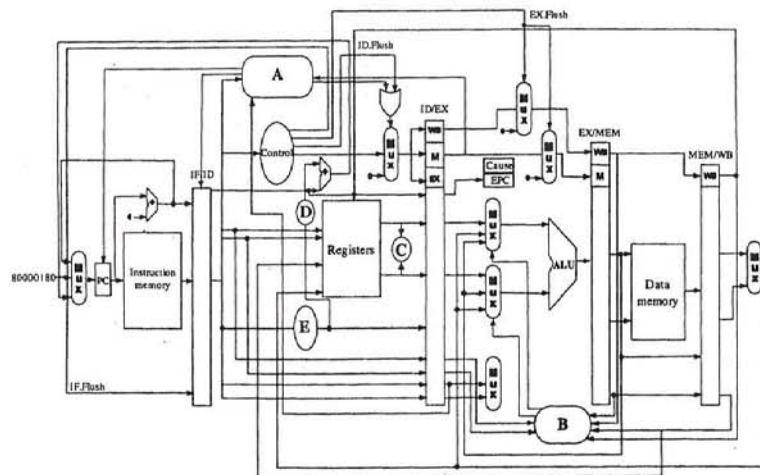
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6. The following figure shows datapath of a pipelining processor.



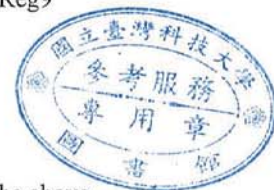
(a) Please make the right binding between each of units "A", "B", "C", "D", "E" and one of following names. (5%)

- ① AND array ② hazard detection unit ③ Forwarding unit
 ④ XOR array ⑤ shift left 2 unit ⑥ sign extend unit
 ⑦ MUX

(b) For the following instruction sequence and assuming that branch (B) is taken. Please describe the instruction pair that causes data hazard, the corresponding depend register, and the unit required to solve the data hazard. (7%)

- (S) sub \$5, \$3, \$4 # Reg5 = Reg3 - Reg4
 (A) add \$1, \$4 \$5 # Reg1 = Reg4 + Reg5
 (D) and \$3, \$2, \$5 # Reg3 = (Reg2 OR Reg5)
 (L) lw \$7, 0(\$1) # Load from MEM (compute base on \$1) to \$7
 (O) ori \$9, \$3, \$7 # Reg9 = (Reg3 OR Reg7)
 (B) beq \$7, \$9, loop # Branch to loop if Reg7 = Reg9
 (R) sra \$3, \$9, 2 # Reg3 = Reg9 >> 2
 (T) slt \$9 \$3, \$7 # Reg9 = 1 if Reg3 < Reg7
 (I) loop: addi \$9, \$7, 40 # Reg9 = Reg7 + 40

(c) Continue with (b). How many cycles does it take to execute the above instruction sequence? (3%)



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7. Below are several functions for computing the square of a number. For each function, what is the Big-Oh estimate of the runtime for each code.

(a) (3%)

```
int square(int n){
    return n*n;}

```

(b) (3%)

```
int square(int n){
    int answer = 0;
    for (int i = 0; i < n; i++){
        answer += i+i+1;}
    return answer;}

```

(c) (3%)

```
int square(int n){
    int answer = 0;
    for (int i = 0; i < n; i++){
        for (int j = 0; j < n; j++){
            answer++;}}
    return answer;}

```

8. (a) Explain what the best case situation is for QuickSort. What is the running time for this case and how do you arrive at this running time? (5%)
 (b) Explain what the worst case situation is for QuickSort. What is the running time for this case and how do you arrive at this running time? (5%)

9. (a) Rewrite the expression the following big-O function in the simplest possible

form: $O(8x \log_7 \frac{y^4}{8} + \max\{3y^4 \log^9 y, 5\sqrt{x}\} + 2^{2y} + 10x \cos x)$.

(No proof is required. Assume $x \geq 2, y \geq 2$) (5%)

(b) Prove formally and rigorously, omitting no details, that:

$x^2 + 10xy + y^2 \in O(x^2 + y^2)$ (Both x and y are positive integers that can grow arbitrarily large.) (5%)



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10. Assume a 10-element hashtable, with $\text{hash}(x) = x \bmod 10$ and linear probing. Show what locations would be probed, in order, for each value in the table, and put the value in its final resting place, if any, in the array: (6%)

Values	Locations probed
71	
23	
73	
99	
44	
79	
89	

Array

0	1	2	3	4	5	6	7	8	9

