資訊工程學系

國立清華大學 101 學年度碩士班入學考試試題

系所班組別：計算機系統

考試科目（代碼）：2002

　*請在【答案卷、卡】作答

1. (8%) Consider the following C program.

```
#include <stdio.h>
#include <unistd.h>

int value = 2;

int main()
{
  pid_t pid;

  do {

    /* fork a child process */
    pid = fork();

    if (pid == 0) {   /* child process */
      value--;
    }
    else {   /* parent process */
      printf("parent: value = %d", value); /* line A */
      fork();
      execlp("\bin\ls");
      /* execlp() loads a new program into memory
        (destroying the memory image of the program
        containing the execlp() system call). */
    }

  } while(value >= 0);

  return 0;
}
```

(a) (4%) After the initial parent process creates the first child process (in the do-while loop), what is the output at `line A`? Justify your answer.

(b) (4%) Including the initial parent process, how many processes are created by the program? Justify your answer.

2. (10%) Consider a single-CPU system with the processes listed below.

Process	Arrival Time (seconds)	*Average* Burst Time (seconds)
P_1	0	5
P_2	10	4

Suppose both the burst time and the remaining time of each process are non-deterministic. The system runs the Shortest-*Expected*-Remaining-Time-First scheduling to allocate the CPU to processes. That is, **the CPU is allocated to the process whose *expected* remaining time is shortest among all the processes.** Suppose that the context-switch time is zero. Assume that the burst times of all these processes are *exponentially distributed* with their means shown in the above table.

Hint 1: The probability density function of an exponential random variable with mean $1/\lambda$ is $f(t) = \lambda e^{-\lambda t}$, $t \geq 0$. Its cumulative distribution function is $F(t) = 1 - e^{-\lambda t}$, $t \geq 0$.

Hint 2: A property of the exponential distribution is that it is memoryless. That is, for an exponential random variable X and any positive constant k, $E[X - k \mid X > k] = E[X]$.

(a) (3%) Given that P_1 completes after P_2 arrives, what is the average waiting time of P_1? (The waiting time is the amount of time during which a process spends waiting in the ready queue.)

(b) (2%) Given that P_1 completes after P_2 arrives, what is the average turnaround time of P_1?

(c) (2%) What is the probability that P_1 completes after P_2 arrives?

(d) (3%) What is the average turnaround time for these processes?

3. (8%) Consider a byte-addressable computer system with a 32-bit virtual address and total physical memory size 64GB. Let paging be implemented for the system with page size 1KB, and each page entry in the page table takes 4 bytes. Answer the following questions:

(a) (2%) If inverted page table is used, what is the memory space required for the page table?

(b) (2%) If one-level page table is used, what is the memory space required for the page table?

(c) (2%) Given a one-level paging, let the memory access time and TLB access time be 300ns and 20ns, respectively. If the TLB hit ratio is 95%, what is the effective memory access time?

(d) (2%) Let's change paging to segmentation. Let the maximum segment size be 1GB. What is the maximum number of segments per process?

4. (10%) Answer the following questions regarding paging:

   (a) (4%) What is trashing? What is the reason for causing trashing?

   (b) (3%) Suppose there is only one process executed by CPU. Given a reference string "012034224", if LRU (least-recently-used) is used with 3 available frames, which reference causes a page fault and which page is replaced when page fault occurs?

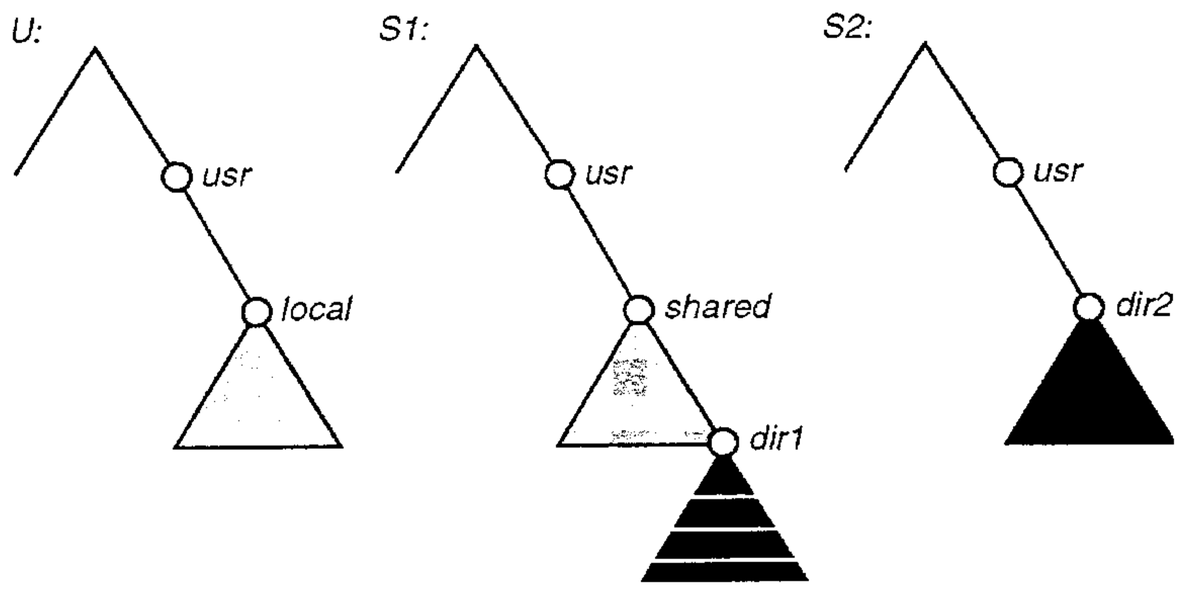
   (c) (3%) What is the working set by the end of the above reference string if the working-set window size is 5?

5. (4%) Consider an operating system which avoids deadlock by using banker's algorithm. Assume the system has four types of resources A, B, C, and D. The total number of instances in the system for A, B, C, D is 4, 14, 14, 10, respectively. The following is a snapshot of the current system-state. ("Allocation" is the number of resource instances currently allocated to each of processes. "Max" is the maximum number of instances that can be requested by each of processes.)

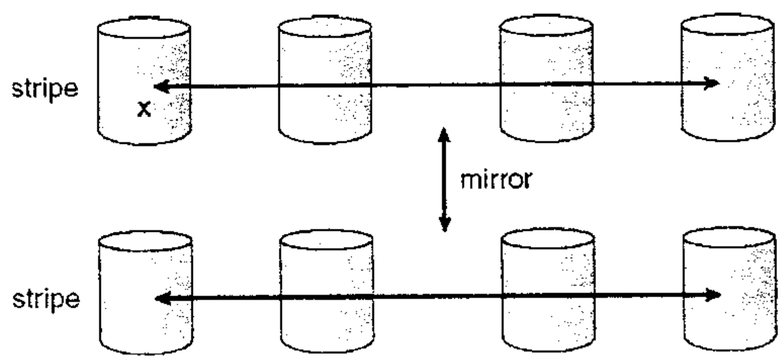
	Allocation				Max			
	A	B	C	D	A	B	C	D
P_0	2	3	4	4	2	3	5	6
P_1	0	3	1	2	3	6	5	6
P_2	0	0	1	2	0	0	1	2
P_3	1	4	3	0	4	7	5	0
P_4	0	1	3	2	0	9	5	2

   If P_3 makes a request of (1, 3, 2, 0), can the request be granted immediately? Why?

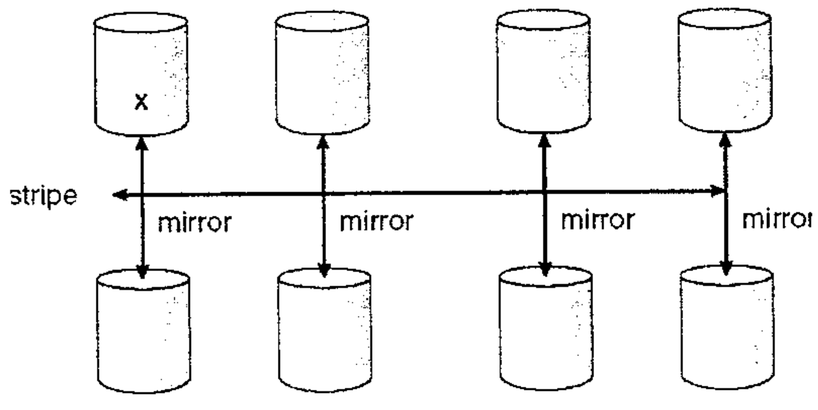
6. (5%) For the following three independent file systems, draw the final file system of U after the following two mountings:
   (1) mounting S1:/user/shared over U:/user/local
   (2) mounting S2:/user/dir2 over U:/user/local/dir1



7. (5%) Explain and compare the features of RAID levels 0+1 and 1+0. For the following figure, explain what happens when RAID 0+1 has a single disk failure and RAID 1+0 has a single disk failure, respectively.



a) RAID 0 + 1 with a single disk failure.



b) RAID 1 + 0 with a single disk failure.

8. (10%) Hexadecimal (base 16) is a popular number system in computers. Hexadecimal numbers are often prefixed with *0x*. Let *x=0xBA09* and *y = 0x3456*. Answer the following questions:

(a) (2%) If x and y represent 16-bit unsigned numbers, what is $x+y$ in hexadecimal?

(b) (2%) If x and y represent 16-bit unsigned numbers, what is $x-y$ in hexadecimal?

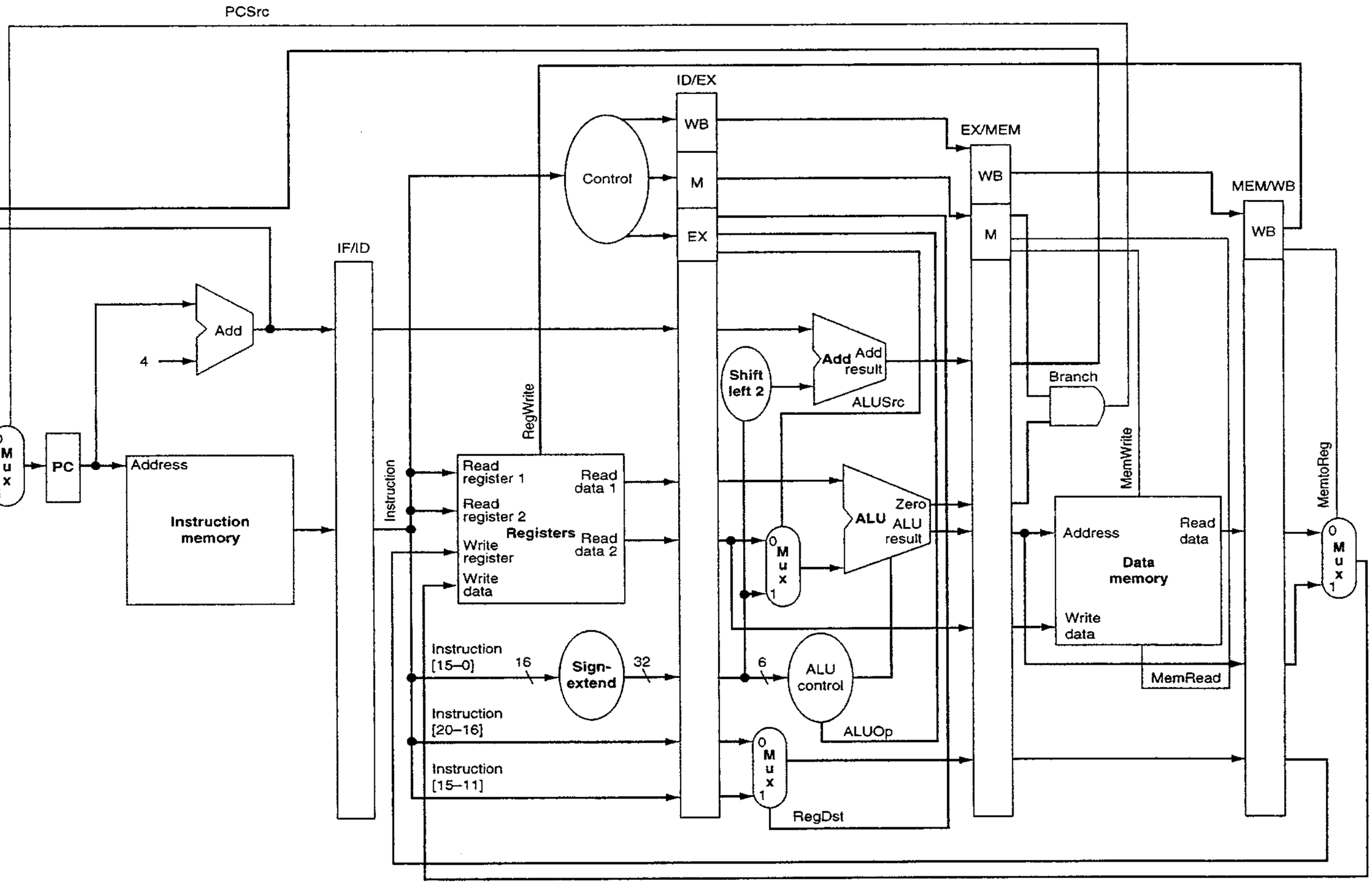
(c) (2%) If x and y represent 16-bit sign-magnitude numbers, where the most

significant bit is the sign bit (1 means negative), what is *x*-*y* in hexadecimal?

(d) (4%) Why hexadecimal is popular among programmers, compared to other number systems?

9. (10%) When each corresponding stage of the CPU shown below is executing the load instruction "`lw $s1, 4($t0)`", the following control values should be:

ALUSrc (0/1)	RegDst (0/1)	MemtoReg (0/1)	PCSrc (0/1)	MemWrite (On/Off)



10. (8%) Given a 32-bit machine, determine the values of the labels ELSE and DONE of the following segment of instructions. Assume that the first instruction is loaded into memory location 8000_{hex}.

```
        slt     $t2,    $t0,    $t0     # set if less than
        bne     $t2,    $zero,  ELSE    # branch if not equal
        j       DONE                    # jump to
ELSE:   addi    $t2,    $t2,    2       # add immediate
DONE:   …
```

11. (12%) Consider a 4-way set-associative write-back cache with 8-byte blocks in a processor that uses 32-bit addresses for a byte-addressable memory. Suppose the cache uses 6-bit indices.

    (a) (4%) Explain how the write-back strategy is implemented.

    (b) (2%) How many sets are there in the cache?

    (c) (2%) How many bits are there in each cache tag?

    (d) (4%) How many bits of storage are required to implement the cache (which include all data, tag, and control items)?

12. (10%) MTBF stands for Mean Time Between Failure, MTTR stands for Mean Time To Repair, and MTTF stands for Mean Time To Failure. These three metrics are important for evaluating reliability and availability of storage devices. Answer the following questions:

    (a) (3%) Define MTBF, MTTR, and MTTF.

    (b) (2%) Considering a disk with an MTTF of 1 year and an MTTR of 1 day, compute its MTBF.

    (c) (2%) Following the previous question, what's the availability of this disk?

    (d) (3%) What's the implication as the MTTR approaches 0? Describe a technique in disk arrays that may result in very low MTTR.