1. (5 points) Both data and instructions are stored in main memory. Can CPU determine whether a main memory location contains an instruction or an operand only by inspecting its contents? If yes, how? If no, what does CPU do?

2. (5 points) Registers R1 and R2 of a computer contain the *decimal* values 3000 and 4400, respectively. What is the effective address of the *memory operand* in each of the following instructions? (a) Add --(R1), R5 (*autodecrement*) (b) Move 50(R2), R5 (*index*) (c) Load 500, R5 (*absolute*) (d) Subtract (R2)+, R5 (*autoincrement*) (e) Store R5, 80(R1, R2) (*index*)

3. (10 points) What is the job of the control unit in CPU? Explain the *micro-programmed* approach to implement the control unit. What are its advantages and disadvantages?

4. (10 points) Consider the following decomposition of the instruction processing: (1) Fetch Instruction, (2) Decode Instruction, (3) Calculate Operand Address, (4) Fetch Operands, (5) Execute Instruction, (6) Write Operand.

   (a) Consider the scope of executing seven instructions only. Show the timing diagram for instruction pipeline operation. What is the performance gain of *pipelining* over *sequential* execution?

   (b) Suppose instruction 3 is a conditional branch to instruction 9. After instruction 3 is completed (a branch instruction does not need the WO stage), instruciton 9 is executed next. Show the timing diagram for instruction pipeline operation over nine fetched instructions. Explain what is *branch penalty* and show its quantity in term of number of cycle.

5. (10 points) A six-stage pipelined processor has TWO branch delay slots. Assume that 20 percent of the instructions executed on a computer are branch instructions. An optimizing compiler can fill one of these slots 90 percent of the time and can fill the second slot only 25 percent of the time.

   (a) What is the percentage of improvement in performance achieved by this optimization?

   (b) Suppose an instruction is executed in time T. What is the throughput of the processor in term of the number of instructions executed per T?

6. (10 points) A byte-addressable computer has a small data cache capable of holding four 16-bit words. Each cache block consists of two 16-bit words. When a given program is executed, the processor reads data from the following sequence of *hexadecimal* addresses: 310, 386, 312, 384, 310, 320, 386, 322, 310, 312. This pattern is repeated TWO times. Show the process of how the contents of the cache are changed if a *direct mapped* cache is used. Computer the hit rate for this example. Assume that the cache is initially empty.

國立政治大學資訊科學研究所入學計算機系統（作業系統）考試考題

7. **(10%)** Consider a computer system consisting of four resources of the type A and four resources of type B that are shared by three processes. Type A and type B resources are bundled in the sense that a process always gets an A if it gets a B, and vice versa. Each of these processes requires no more than two resources of type A and two resources of type B. **Is this system deadlock-free? Show a proof for your answer.**

8. **(10%)** Consider a single-CPU computer system that adopts the well-known FCFS (first-come, first-serve) algorithm for CPU scheduling. Assume that the CPU is idle before three independent processes simultaneously arrive at the system at time 5, and that the execution times of these processes have a common normal distribution with mean 3 and standard deviation 3. **When is the system expected to complete all three processes?** Now assume that the system adopts the round-robin scheduling algorithm, that the time quantum is 1 time unit, and that it takes 1 time unit for the system to carry out context switch. **When is the system expected to complete all three processes?**
Note that you must show and explain how you get your answer in your answer sheet. Answers without explanation will receive no credits.

9. **(10%)** Consider the following programs to be executed in a computer system that employs demand paging for memory management.

```
main()                          main()
{                               {
int i, j, fun[200][200];        int i, j, fun[200][200];
for (i=0; i<200; i++)           for (j=0; j<200; j++)
    for (j=0; j<200; j++)           for (i=0; i<200; i++)
        fun[i][j] = 0;                  fun[i][j] = 0;
return 0;                       return 0;
}                               }
```

Assume that, in this language, the array is stored column major, and that the operating system allocates 128 pages of 256 words to an individual program. **Which program, left one or right one, would run faster? Why? Answer these questions again, but assume that the operating system allocates 256 pages of 512 words to programs?**

10. **(10%)** Answer the following questions about computer security.
    10.1 **(5%)** A company modernized its information system by introducing Intranet and Internet services. The general manager hired a top computer specialist to install a waterproof firewall to protect the computers of the company from unauthorized accesses. The system run pretty well for a while until one day the main host computer of the company was broken in, and important documents were apparently damaged. **Do you think this could happen in reality? Provide a good technical reason for your answer.**
    10.2 **(5%)** UNIX systems that employ encryption function to encode users' passwords typically do not allow people to use as passwords words that can found in dictionaries. **Provide a technical reason for the precautionary check.**

11. **(10%)** Briefly and precisely answer the following questions.
    11.1 **(3%)** Explain the main similarity and difference between job scheduling and CPU scheduling.
    11.2 **(4%)** Explain the main similarity and difference among the following techniques: segmentation, paging and caching.
    11.3 **(3%)** Explain why a process may be "swapped".