※注意：1. 請於答案卷上標明作答之大題及其題號
2. 請務必依照題號作答

1. (20 pts) Answer the following questions **(2 pts each)**:

(1) Define *loop invariant* in program verification.

(2) Give an *object-oriented programming language*. Also give one for *functional programming*.

(3) What is the difference between *semantics* and *syntax?*

(4) Write -2 as a four-bit binary number in *two's complement* notation.

(5) You have hired a programmer to develop a new network-based accounting system. The programmer chooses the UDP protocol for all communication within the system, and finds out when testing a prototype for the system that the network is throwing away half of the UDP packets, which will cause massive loss of data, and legal liability when the system is put into use. Suggest a simple solution to this problem. Why?

(6) Draw a circuit using only 2-input AND gates that produces a 1 as output only if all four of its inputs are 1.

(7) Define *tail recursion*.

(8) What are the worst-case running times of *quick-sort* and *merge-sort?*

(9) What is the main difference between '*passed by value*' and '*passed by reference*' in procedure call?

(10) What is *Church-Turing thesis*?

2. (10 pts) Explain what each of the following UNIX commands does. **(2 pts each)**

(1) *ls* (2) *cd* (3) *cp example.c proj2.c* (4) *rm example.c* (5) *man passwd*

3. (5 pts) Write a *recursive* function, *FindSum*, in C that calculates the sum of successive integers starting at 1 and ending at *N*. For example: *FindSum(N)* returns the sum of $1 + 2 + ... + N$. Also write an *iterative* version of *FindSum*.

4. (10 pts) How many times do each of the bodies of the following loops execute (you may assume that i is not changed in the loop body)? (Write '*infinite*' if the number is not bounded by any constant.) **(2 pts each)**

(1) *for (int i = 1; i <= 10; i++) // body*

(2) *for (int i = 10; i > 0; i --) // body*

(3) *for (int i = -10; i <= 10; i++) // body*

(4) *for (int i = 10; i > = 0; i++) // body*

(5) *for (int i = -10; i <= 10; i = i + 2) // body*

5. (5 pts) Five algorithms for solving some unspecified problem have asymptotic running times

$\Theta(n \log n)$, $\Theta(\log^5 n)$, $\Theta(n^{0.00001})$, $\Theta(2^n)$, and $\Theta(n^2)$.

1. **(3 pts)** Order these running times from smallest to largest.
2. **(2 pts)** Which of these running times puts the corresponding algorithm in the complexity class P?

接背面

6. (20 pts) A certain machine with a 10ns (10×10^{-9} s) clock period can perform *jumps* (1 cycle), *branches* (3 cycles), *arithmetic instructions* (2 cycles), *multiply instructions* (5 cycles), and *memory instructions* (4 cycles). A certain program has *10% jumps, 10% branches, 50% arithmetic, 10% multiply,* and *20% memory* instructions. Answer the following questions **(5 pts each)**. Show your derivation in sufficient detail.

(1) What is the CPI of this program on this machine?

(2) If the program executes 10^9 instructions, what is its execution time?

(3) A 5-cycle *multiply-add* instruction is implemented that combines an *arithmetic* and a *multiply* instruction. 50% of the *multiplies* can be turned into multiply-adds. What is the new CPI?

(4) Following (3) above, if the clock period remains the same, what is the program's new execution time?

7. (10 pts) Answer **true (O)** or **false (X)** for each of the following. **(NO penalty for wrong answer.)**

(1) Most computers use direct mapped page tables.

(2) Increasing the block size of a cache is likely to take advantage of temporal locality.

(3) Increasing the page size tends to decrease the size of the page table.

(4) Virtual memory typically uses a write-back strategy, rather than a write-through strategy.

(5) If the cycle time and the CPI both increase by 10% and the number of instruction deceases by 20%, then the execution time will remain the same.

(6) A page fault occurs when the page table entry cannot be found in the translation lookaside buffer.

(7) To store a given amount of data, direct mapped caches are typically smaller than either set associative or fully associative caches, assuming that the block size for each cache is the same.

(8) The two's complement of negative number, is always a positive number in the same number format.

(9) A RISC computer will typically require more instructions than a CISC computer to implement a given program.

(10) Pentium 4 is based on the RISC architecture.

8. (10 pts) The average memory access time (AMAT) is defined as

AMAT = hit_time + miss_rate × miss_penalty

Answer the following two questions. Show your derivation in sufficient detail.

(1) **(5 pts)** Find the AMAT of a machine 100 MHz machine, with a miss penalty of 20 cycles, a hit time of 2 cycles, and a miss rate of 5%.

(2) **(5 pts)** Suppose doubling the size of the cache decrease the miss rate to 3%, but causes the hit time to increases to 3 cycles and the miss penalty to increase to 21 cycles. What is the AMATof the new machine?

9. (10 pts) If a pipelined processor has 5 stages and takes *100 ns* to execute *N* instructions. How long will it take to execute *2N* instructions, assuming the clock rate is *500 MHz* and no pipeline stalls occur? Show your derivation in detail.