

考試科目	計算機概論	開課系級	資訊科學系	日期	4月24日	試題編號	
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- (B) manage, load, and execute program
- (C) manage hardware resources of the computer
- (D) develop and debug program

[3%] 8. Which one of the following statements is false?

- (A) A data structure is a tool for managing data
- (B) A stack is not accessed in the same way as an array.
- (C) An abstract data type combines the logical definition of a data structure with its physical implementation.
- (D) A queue can be efficiently implemented as a circular array.

[10%] 9. Using C/C++, PASCAL, FORTRAN or BASIC, write a computer program to find f_{10} and f_{100} of Fibonacci numbers and print the results on the screen.

The Fibonacci numbers is defined as:
$$\begin{cases} f_n = f_{n-1} + f_{n-2} & , \quad n \geq 2 \\ f_0 = 0 & , \quad f_1 = 1 \end{cases}$$

[6%] 10. What will be printed if we execute the following C program?

```
int mess (int x)
{
    int i, y = x;
    if ( y > 3) return y;
    for (i = 1 ; i <= x; i++)
        y = mess(y+i);
    return y;
}

main()
{
    printf("%d\n", mess(3));
}
```

[8%] 11. In the software life cycle, the "waterfall model" describes six phases: Needs analysis, needs specification, algorithm design, software implementation, testing and integration, delivery and operation. As a non-CS majored person like you, explain how you can cooperate tightly with a CS majored person in the above waterfall model of the software life cycle. Can you explain this by illustrating an example?

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application programs for a computer system? You can make an example to illustrate this.

[8%] 13. In comparisons of computers and human brains, can you name 2 features that most describe the advantages of computers over human brains?

[8%] 14. In recent internet in Taiwan, we often encounter network congestion, can you address two effective solutions to reduce the congestion probability? Please also explain why?

[8%] 1. (a) In computer number systems, suppose we use 4 bytes to represent a floating number. Of 32 bits, we use 1 bit for "sign" bit, 6 bits for exponent, 25 bits for mantissa. What will be approximate number of significant figures of precisions? (4%)

(b) Construct the truth table for the Boolean function f defined as

$$f(x, y, z) = (NOT\ x \ OR \ NOT\ z) \ AND \ NOT(x \ OR \ y)$$

(4%)

[10%] 2. What will be printed if we execute the following C program?

```
int xxx(int *a)
{
    int y = *a;
    if (y > 2) return y;
    (*a)++;    y += 2;
    return xxx(&y);
}

main()
{
    int a = 1;
    printf("xxx=%d\n", xxx(&a));
    printf("a=%d\n", a);
}
```

[8%] 3. (a) In recent internet in Taiwan, we often encounter network congestion, can you address 2 effective solutions to reduce the congestion probability?

Please also explain why? (4%)

(b) State two features that best describe the object-oriented paradigm. (4%)

[5%] 4. Please design a Turing Machine M to accept the language $L = \{ 0^n 1 \mid n \geq 1 \}$.

(Note: M should be denoted at least by a finite set of states Q , a finite set of allowable tape symbols Σ , a set of input symbols, the next move function δ , the initial state q_0 , and the final state q_f)

[4%] 5. A compiler designer is trying to decide between two code sequences for a particular machine. The hardware designers have supplied the following facts: (Note: CPI means average number of clock cycles each instruction takes to execute)

Instruction class		CPI for this instruction class	
A		1	
B		2	
C		3	

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

Instruction counts for instruction class			
Code sequence	A	B	C
1	2	1	2
2	4	1	1

Which code sequence executes the most instructions? Which will be faster? What is the CPI for each sequence?

[10%] 6. Given an integer N and a sequence of integers $a_0, a_1, \dots, a_m$

- (1) please design an efficient algorithm run in $O(\log N)$ to compute N^w . (5%)
- (2) please give an algorithm run in $O(N)$ to evaluate the polynomial
- $$a_N N^w + a_{N-1} N^{w-1} + \dots + a_1 N^1 + a_0. \quad (5\%)$$

[5%] 7. Please describe the reasons why internal sorting algorithms are not efficient when the input data is too large to fit in main memory?

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[10%] 8. In the following sequence of 10 records, each record consists of three attributes, namely *name*, *age* and *weight*. These records are input in sequence, (Mary, 20, 45), (Steven, 55, 90), (Tom, 35, 60), (Bill, 25, 60), (Adam, 30, 55), (Helen, 15, 40), (David, 28, 80), (Jane, 37, 60), (George, 10, 30), (John, 50, 70).

(a) Please show the result of inserting the above records using the following data structure in memory to support query *age* by *name*? An example of query is to show the age of Jane. Only the final result is required.

(1) AVL tree. (3%)

(2) B'-tree of order 3. (3%)

(b) Assume that each name is queried with the same probability. For each of the above data structure established from these 10 records, please calculate the average number of comparisons required to support the query. (4%)

[5%] 9. In the WWW browser, users click the **Back** button to display the previous page in the *history list*. For example, starting from the page A and linking to the page B, clicking the **Back** button will go back to the page A. How to implement the *history list* and the **Back** operations? Please describe the data structure and the corresponding operations.

[10%] 10. In quick sort, there are several strategies to pick the pivot. What is the worst case for quick sort algorithm using each of the following pivot picking strategies respectively? For each strategy, please give an example with 7 elements and show the sorting process (you must show the result after each pass.)

(1) Pick the first element as the pivot. (3%)

(2) Pick the center element (not the element with median value) as the pivot. (4%)

(3) Pick the last element as the pivot. (3%)

[15%] 11. Given the following graph,

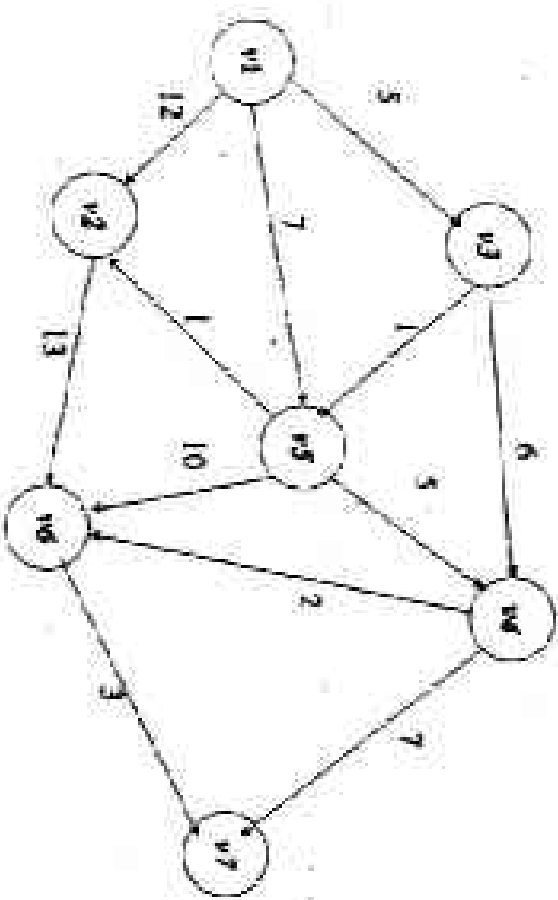
(1) how to represent the graph? Please show two different ways using the graph. (2%)

(2) use Dijkstra's algorithm to find the shortest paths from *v1* to every other vertex. (5%)

(3) design an algorithm to find a path between two given nodes, such that the number of vertices along the path is minimum. What is the time

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complexity of your algorithm. (8%)



[10%] 12. In the binary trees, the balance factor of a node v is defined as the difference between the height of v 's left subtree and the height of v ' right subtree. Please design an algorithm to find the balance factors in a binary tree based on one of the well-known graph traversal algorithms.

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國立政治大學圖書館

The Master Program Entrance Exam. for Computer Science
Dept.

Computer Systems: Operating Systems

There are five problems in this computer systems: operating systems examination. Please do all of them. The weight for each problem is indicated after the problem number.

- (10%) What is virtual-machine operating system architecture? What is the main advantage of an operating-system designer of using a virtual-machine architecture? What is the main advantage for a user?
- (10%) *The Sleeping-Barber Problem*. A barbershop consists of a waiting room with 5 chairs, and the barber room containing the barber chair. If there are no customers to be served, the barber goes to sleep. If a customer enters the barbershop and all chairs are occupied, then the customer leaves the shop. If the barber is busy, but chairs are available, then the customer sits in one of the free chairs. If the barber is asleep, the customer wakes up the barber. Write a C program to coordinate the barber and the customers.
- (10%) Three different protection mechanisms are capabilities, access control lists, and the UNIX *rwx* bits. For each of the following protection problems, tell which of these mechanisms can be used.
 - Rick wants his files readable by everyone except Jennifer.
 - Helen and Anna want to share some secret files.
 - Cathy wants some of her files to be public.

For UNIX, assume that groups are categories such as faculty, students, secretaries, and so on.

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4. (10%) Consider a demand-paging system with the following time-measured utilization:

CPU utilization	20%
Paging disk	97.7%
Other I/O devices	5%

Which(if any) of the following will (probably) improve CPU utilization? Explain your answer.

- (a) Install a faster CPU.
 - (b) Install more main memory
 - (c) Increase the degree of multiprogramming.
 - (d) Increase the page size.
 - (e) Install a faster hard disk, or multiple controllers with multiple hard disks.
5. (10%) SUN NFS aims to support heterogeneous distributed systems by the provision of an operating system-independent file service. What are the key decisions that the implementator of an NFS server for an operating system other than UNIX would have to take? What constraints are there on an underlying filing systems that would be suitable for the implementation of NFS servers?

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計算機組織與結構

- (10 points) The goal of designing computer architecture and organization is to increase program execution rates. Many important techniques can be generalized into three major concepts (approaches). What are these concepts? Briefly explain how they work?
- (10 points) A *daisy chain* is a widely used scheme to connect I/O devices. List two situations in which the scheme can be used in I/O operations and explain how it works.
- (10 points) Consider the control unit operation in the instruction fetch and the indirect addressing cycles only. List the micro-operations and the control signals needed to execute each cycle.
- (10 points) A computer system contains a main memory of 32K 16-bit words. It also has a 4K-word cache divided into 4-slot(line) sets with 64 words per slot. Assume that the cache is initially empty. The processor fetches words from locations 0, 1, 2, ..., 4351 in that order. It then repeats this fetch sequence 9 more times. The cache is 10 times faster than main memory. Estimate the improvement resulting from the use of the cache. Assume an LRU policy for block replacement.
- (10 points) Consider a three-stage (fetch, execute - calculate memory address, read/write) pipeline for instructions that involve memory access, such as LOAD and STORE. All other instructions are pipelined in two stages (fetch, execute). For the following program:

```

100  LOAD  X, A
101  ADD   #1, A
102  JUMP  105
103  ADD   A, B
104  SUB   C, B
105  STORE A, Z

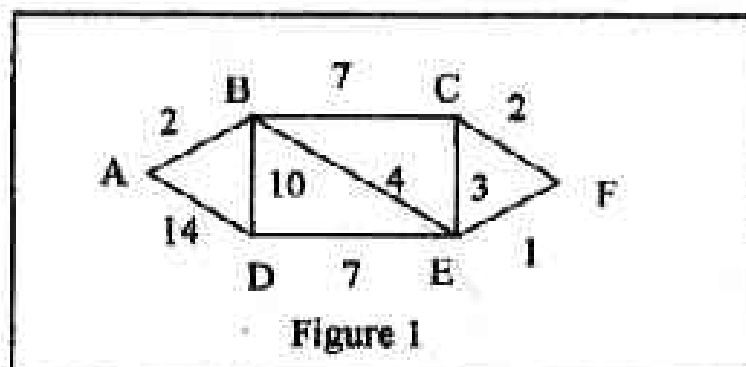
```

- Show the *branch delay slot* in the timing diagram.
- Explain the *delayed branching* technique. Show the new timing diagram.

第一單元：離散數學 (本單元共計 60 分)

I. 單選題：(每題 3 分，答錯不倒扣)

- Which of the following functions grows asymptotically faster than all others ?
(a) $100n^{10}$ (b) $\log(n!)$ (c) $n \log n$ (d) $(\log n)^{(\log n)}$
- Consider the simple program segment S: $\{X = X + 1; Y = X - Y\}$, where X and Y are integer variables. Suppose, after execution of S, we find that $X > 2Y$. Then which of the following statement must hold before the execution of S ?
(a) $Y > X$ (b) $X > Y$ (c) $X < 2Y$ (d) $X > 2Y$ (e) $X = 2Y$
- Let $G=(V,E)$ be a graph where $V = \{x \mid x \in \{0,1\}^{10} \text{ is a bit string of length 10}\}$ and $E = \{(x,y) \mid x \text{ differs from } y \text{ in exactly 2 positions}\}$. Then what is the value of $|E|$?
(a) $2^{11} \times 25$ (b) $2^{10} \times 45$ (c) $2^9 \times 45$ (d) $2^{11} \times 45$
- Which of the following equalities is not valid in Boolean algebra ? Where $+$, $*$ and $-$ are Boolean operators corresponding to logical OR, AND and NOT, respectively.
(a) $x + y = y + x$ (b) $x * (y + z) = (x*y) + (x*z)$ (c) $x + (y * z) = (x*y) + (x*z)$ (d) $\neg(x + y) = \neg x + \neg y$
- Which of the following languages is regular (i.e., can be accepted by a finite automata) ?
(a) $\{0^n 1^n \mid n > 0\}$ (b) $\{1^n \mid n \text{ is a prime number}\}$ (c) $\{1^n \mid n = 2^k \text{ and } k > 0\}$
(d) $A/2 =_{\text{def}} \{x \mid \text{there is a string } y \text{ s.t. } |x|=|y| \text{ and } xy \in A\}$, where A is a regular language.
- If we apply Dijkstra's algorithm to find the shortest distances between vertex A and all other vertices in the weighted graph shown in Figure 1, then what is the vertex whose distance from A would be determined last ?
(a) C (b) D (c) E (d) F



- Let T be a tree with 41 vertices. The removal of a certain edge from T yields two disjoint trees T1 and T2. Given that the number of vertices in T1 equals the number of edges in T2, then what is the sum of the number of edges in T1 and the number of vertices in T2?
(a) 39 (b) 40 (c) 41 (d) 42

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II 複選題: (每題 3 分. 每一題目有四個選項, 不倒扣, 但全對才給分)

8. Let P, Q, R be any statements and S a program. If the Hoare triple $P\{S\}Q$ holds. Then which of the following triples hold as well? Where $\wedge$ and $\vee$ are logical AND and logical OR operations, respectively.

- (a) $(P \vee R)\{S\}Q$ (b) $P\{S\}(Q \vee R)$ (c) $(P \wedge R)\{S\}Q$ (d) $P\{S\}(Q \wedge R)$

9. Let $N = \{0, 1, 2, \dots\}$ be the set of natural numbers and $R = \{(x, y) \mid x \text{ divides } y\}$ is a relation defined on N . Then which of the following statements are correct for (N, R) .

- (a) (N, R) is a poset, (b) (N, R) is a lattice (c) (N, R) has no maximum element
(d) 0 is the unique minimum element of (N, R)

10. Which of the following statements are correct?

- (a) The chromatic number of every graph is no greater than 4.
(b) Two graphs are isomorphic if and only if they have the same numbers of vertices and edges.
(c) A simple graph is connected if and only if it has a spanning tree.
(d) A complete graph with 10 vertices contains no less than 50 edges.

III. 計算與證明題: (共 30 分)

1. (8 pts) A palindrome over an alphabet Σ is a string over Σ whose reversal is identical to the string. Let A_n ($n = 0, 1, \dots$) be the number of palindromes of length n over $\Sigma = \{1, 2, 3, 4\}$.

- (a) what are A_0 and A_1 ? (2pts)
(b) Find a recurrence relation for A_n ($n > 1$). (3 pts)
(c) Solve the above recurrence relation and find a general solution for A_n . (3 pts)

2. (10 pts) Let A be any set, and let $f: 2^A \rightarrow 2^A$ be any monotonic function on subsets of A (i.e., for all subsets X and Y of A , $X \subseteq Y$ implies $f(X) \subseteq f(Y)$). This problem is to show that there exists a set T such that $f(T) = T$ (T is called a fixed point of the function f). We simply let $T = \bigcap \{X \mid X \subseteq A \text{ and } f(X) \subseteq X\}$ be the intersection of all subsets X of A with $f(X) \subseteq X$. Now prove $f(T) = T$ by showing that (a) $T \subseteq f(T)$ and (b) $f(T) \subseteq T$.

3. (12 pts) Let $L = \{xlab \mid x \in \{0, 1\}^* \text{ and } a, b \in \{0, 1\}\}$ be the set of bit strings of which the third bit from the right is 1. Let R be a binary relation on the set of all bit strings $\{0, 1\}^*$ such that for any bit strings x, y , $(x, y) \in R$ iff $\forall z \in \{0, 1\}^* (xz \in L \text{ iff } yz \in L)$.

- (a) Show that R is an equivalence relation on $\{0, 1\}^*$. (3 pts)
(b) Show that for all bit string x and y and for any bit $a \in \{0, 1\}$, $(x, y) \in R$ implies $(xa, ya) \in R$ (3 pts)
(b) What is the equivalence class of 01 with respect to R ? (3 pts)
(c) How many equivalence classes are there with respect to the relation R ? (3 pts)

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第一單元：

請就下列「機率」和「線性代數」二科中選擇其中一科作答

機率 (40%)

(20%) (1) 某公司對該公司所生產的某項產品進行測試，其測試標準為若該產品在一個月內正常運轉時發生錯誤的次數超過兩次以上(含兩次)，即認定該產品為瑕疵品，而被丟棄。該產品每月發生錯誤的次數，依過去的經驗是呈卜氏分配，而其參數為 0.01。請問此產品在一年內不會被丟棄的機率為多少？

(20%) (2) 令 X 為一離散隨機變數，其機率密度函數如下，試求 X 之期望值。

$$f(x) = \begin{cases} \frac{6}{\pi^2} \frac{1}{x^2}, & x=1, -2, 3, -4, \dots \\ 0, & \text{其他} \end{cases}$$

線性代數 (40%)

(20%) (1) 解聯立方程組

$$\begin{cases} x_1 + 3x_2 - 4x_3 - 5x_4 = 1 \\ 2x_1 - x_2 + 3x_3 + 2x_4 = -5 \\ x_1 - 11x_2 + 18x_3 + 19x_4 = -13 \end{cases}$$

(20%) (2) 設

$$A = \begin{bmatrix} 2 & -3 & 1 \\ 7 & 0 & 2 \\ 12 & 4 & 3 \end{bmatrix}$$

求出可逆方陣 P ，使得 $A = PUP^{-1}$ ，其中 U 為上三角矩陣，其對角線值為 A 之固有值。

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[10%] 1. In computer number systems,

- if we use 4 bytes (i.e. 32 bits) to represent an unsigned integer (including 0), what is the maximum integer that we can represent using the number system? (2%)
- if we use 4 bytes to represent an integer and use 2's complement for negative integers, what are the maximum positive and the minimum negative integers we can represent, respectively? (2%)
- Please convert the decimal number 1234 to a binary number. (2%)
- For a floating number, we can use 4 bytes to represent. Of 32 bits, we use 1 bit for "sign" bit, 6 bits for exponent, and 25 bits for mantissa. What will be approximate number of significant figures of precisions? (4%)

[10%] 2. (a) Name 3 major components in a central processing unit (CPU). Explain briefly their functions, respectively. (6%)

(b) Name 2 peripheral input and 2 output devices, respectively. (4%)

[4%] 3. Construct the truth table for the Boolean function f defined as

$$f(x, y, z) = (\text{NOT } x \text{ OR } \text{NOT } z) \text{ AND } \text{NOT}(x \text{ OR } y)$$

[6%] 4. We consider only 1 clerk in a bank, and assume the clerk serves 1 customer at a time. Customers A, B, C, D arrive at the same time, and need 1, 2, 3, 4 minutes of service, respectively. The customers who are not being served will wait. The time from arrival until getting served is called "waiting time". To get the minimum total waiting time for all the 4 customers, how do you choose the service order for the 4 customers?

[8%] 5. (a) Compare the differences among assemblers, compilers, and interpreters. (4%)

(b) In virtual memory design, what is the meaning for a "page fault". (4%)

[8%] 6. Suppose you want to sort 3 distinct integers, x, y, z in an increasing order. Write down your method showing how to perform this task. You need to write a step-by-step algorithm or show it by a flow chart.

[3%] 7. Which one of the followings is not the basic type of services for the Operating System?

(A) accept and execute commands