一、選擇題 (題目 1 到題目 5，每題三分。)

【 】1. An algorithm must _____.
(A) halt in infinite amount of time (B) always receive input (C) be a partially ordered collection (D) consist of unambiguous and effectively computable operations

【 】2. If a Turing machine program consists of the following four instructions:
(1,0,1,2,R)
(1,1,0,2,R)
(2,0,0,2,R)
(2,b,b,2,L)
then which of the following is a halting configuration?
(A) ... b 1 1 b b b ... (current state = 2, symbol 1 is being read)
(B) ... b 1 1 b b b ... (current state = 1, symbol 1 is being read)
(C) ... b 1 0 b b b ... (current state = 1, symbol 0 is being read)
(D) ... b 1 0 b b b ... (current state = 2, symbol 0 is being read)

【 】3. Assume that a sequence (15, 13, 28, 30, 41, 12, 5, 62) is sorted by a quick sort. Which of the follow statement is incorrect after the first pass? (A)The first element is 12, (B) The third element is 13, (C)The fourth element is 15, (D) The last element is 62.

【 】4. Given the sequence (15, 13, 28, 30, 41, 12, 5, 62) to construct an AVL tree. Which of the following statement is incorrect? (A)15 is the root, (B)12 is an internal node, (C)41 is a leaf, (D)28 is a leaf.

【 】5. As the graph shown in Fig. 1, which of the following sequence is not a legal topological order? (A) ABCDEGHF (B) ACBEGHDF (C)ACEBGDHF (D)ABCGHDEF

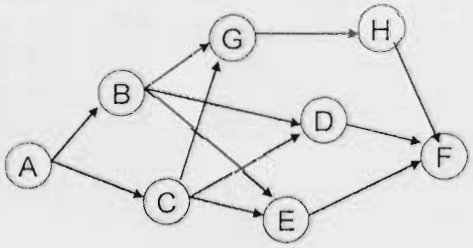


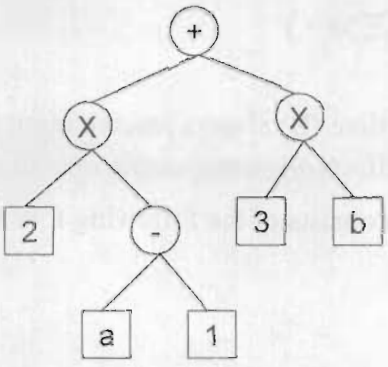
Fig. 1 Graph for problem 5.

二、簡答題

1. (10 points) Describe the concept of stored-program.
2. (10 points) Explain the model of client/server. You can give your answer in many different aspects such as the basic concept of the model, client/server model's applications, advantages and disadvantages compare with other types of models, and so on.
3. (10 points) Explain the following terms: (a) boot program (b) applet (c) API (d) GUI (e) ADT
4. (10 points) Would a large array or an object be passed to a subroutine by value? Yes or No? Give reasons to sustain your judgment.
5. (10 points) Write a pseudo code to printout an arithmetic expression that is stored in an arithmetic expressi tree. The following diagram shows an example of the arithmetic expression tree with the expression: (2 x -1) + (3 x b)).

國立雲林科技大學
97學年度碩士班入學招生考試試題

系所：資工所
科目：計算機概論



6. (5 points) For what input sizes n in an algorithm that does $50n+500$ units of work slower than an algorithm that does $10n^2$ units of work? For what input sizes is it faster?
7. (4 points) (a) An algorithm that is $O(n)$ takes 10 seconds to execute on a particular computer when n=100. How long would you expect it to take when n=500?
   (b) An algorithm that is $O(n^2)$ takes 10 seconds to execute on a particular computer when n=100. How long would you expect it to take when n=500?
8. (5 points) What are the advantages and disadvantages of using a dynamically created list over a statically created one?
9. (10 points) Draw diagrams and write the pseudo codes to explain how to implement the stack in a linked list.
10. (5 points) How many bits would it take to store an uncompressed 1200x800 RGB color image? If we found out that the image actually took only 2.4Mbits, what would be the compression ratio?
11. (6 points) What do the following programs do?

(a)
```
#include <iostream>
using std::cout;
using std::endl;

void someFunction( int [], int, int );

int main()
{
   const int arraySize = 10;
   int a[ arraySize ] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 };
   cout << "The values in the array are:" << endl;
   someFunction( a, 0, arraySize );
   cout << endl;
   return 0;
}

void someFunction( int b[], int current, int size )
{
   if ( current < size )
   {
      someFunction( b, current + 1, size );
      cout << b[ current ] << "  ";
   }
}
```

(b)
```
#include <iostream>
using std::cout;
using std::cin;
using std::endl;

int mystery2( const char * );

int main()
{
   char string1[ 80 ];
   cout << "Enter a string: ";
   cin >> string1;
   cout << mystery2( string1 ) << endl;
   return 0;
}

int mystery2( const char *s )
{
   int x;
   for ( x = 0; *s != '\0'; s++ )
      ++x;
   return x;
}
```

1. For each of the following Boolean expressions, answer the three questions: decide if it is (i) valid, (ii) satisfiable, (iii) unsatisfiable. (Give all applicable properties, with justifications.) (15 points)
   (a) $A \wedge \neg A \wedge \neg B$. Is it valid? Is it satisfiable? Is it unsatisfiable? (5 points)
   (b) $(A \Rightarrow B) \wedge (B \Rightarrow C) \wedge (C \Rightarrow \neg A)$. Is it valid? Is it satisfiable? Is it unsatisfiable? (5 points)
   (c) $(A \Rightarrow B) \vee (B \Rightarrow A)$. Is it valid? Is it satisfiable? Is it unsatisfiable? (5 points)

2. Given a binary tree t, the depth depth(f, t) of a leaf f in t is defined to be the length of the path from f to the root of f. (Hence, if t is just an atom f, then depth(f, t)=0). (25 points)
   (a) Let children(r, A, children(n, B, C)) represent a tree t with root r having A as its left child and the node n as its right child, and n has left child B and right child C. In this tree t, what are the depths of the 3 leaves A, B, C. (5 points)

   (b) If a leaf f is a leaf of tree t_1 and depth(f, t_1)=d, and t_2 is some other tree, what is the value of depth(f, children(r_1, t_1, t_2))? (You do not need to prove your answer.) (5 points)

   (c) Let us define

   $L(t) = \sum_{f \text{ if is a leaf of } t} \frac{1}{2^{depth(f,t)}}$

   Verify that L(t) = 1 for the tree t in (a). (5 points)
   (d) Using tree induction, show that L(t)=1 for every binary tree t. (You may use the result of part (2b) as a lemma here without giving the proof.) (10 points)

3. A map is a set of n countries $C_1,\ldots,C_n$, plus a specification of which countries C_i are adjacent to which countries C_j. A feasible 2-coloring assigns one of two colors to each country, such that no adjacent countries have the same color. (For example, the squares of a chessboard have a feasible 2-coloring.) Given a map, explain how to construct a CNF expression that is satisfiable iff a feasible 2-coloring exists for the map. (10 points)

國立雲林科技大學
97 學年度碩士班入學招生考試試題

系所：資工所
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4. (10%) Prove that for all $n \in Z^+$, $n>3 \Rightarrow 2^n < n!$

5. (10%) For every positive integer n, show that $\binom{n}{0}+\binom{n}{2}+\binom{n}{4}+\cdots=\binom{n}{1}+\binom{n}{3}+\binom{n}{5}+\cdots$

6. (10%) Allen writes the consecutive integers 1, 2, 3, … , n on a blackboard. Then Barbara erases one of these integers. If the average of the remaining integers is $35\frac{7}{17}$, what is n and what integer was erased?

7. (10%) With A = $\{x, y, z\}$, let f, g:A→A be given by $f=\{(x, y), (y, z), (z, x)\}$, $g=\{(x, y), (y, x), (z, z)\}$. Determine each of the following: $g \circ f, f^{-1}, g^{-1}, (g \circ f)^{-1}, (f^{-1} \circ g^{-1})$

8. (10%) Let A=$\{1,2,3,4,5\} \times \{1,2,3,4,5\}$, and define $\Re$ on A by $(x_1, y_1) \Re (x_2, y_2)$ if $x_1 + y_1 = x_2 + y_2$.
   (a) Determine the equivalence classes [(1, 3)], [(2, 4)], [(1, 1)].
   (b) Determine the partition of A induced by $\Re$.

國立雲林科技大學
97學年度碩士班入學招生考試試題

系所：資工所
科目：作業系統

題目1至題目10爲多選題，每題5分。每題需全部答對才給分，答錯倒扣1分。

1. Which are correct for traps?
   (A) Events are almost always signaled by the occurrence of an interrupt or a trap.
   (B) A trap is a hardware-generated interrupt caused by an error.
   (C) A trap could be an interrupt caused by a specific request from a user program.
   (D) Invalid memory access would cause a trap.

2. Which are correct for system boot?
   (A) The procedure of starting a computer by loading the kernel is known as booting the system.
   (B) Booting is definitely a one-step process in which a bootstrap loader locates the kernel and loads it into main memory.
   (C) When a CPU receives a reset event, the instruction register is loaded with a predefined memory location where the initial bootstrap program is located.
   (D) The bootstrap program must be stored in the boot block.

3. What information would a process control block contain?
   (A) CPU registers
   (B) I/O status information
   (C) memory-management information
   (D) accounting information

4. Which are correct for threads?
   (A) In UNIX systems, if exec() is called immediately after forking(), duplicating all threads is necessary.
   (B) Pthreads refers to the POSIX standard defining an API for thread creation and synchronization.
   (C) For delivering signals to threads, the signal that terminates a process should be sent to all threads.
   (D) Windows XP uses the many-to-one model for mapping between user-level threads and kernel threads.

5. What would the criteria include for comparing CPU scheduling algorithms?
   (A) throughput
   (B) turnaround time
   (C) context-switch time
   (D) waiting time

6. Which are correct for synchronization?
   (A) Both TestAndSet() and Swap() instructions can be used to solve the critical-section problem.
   (B) The main disadvantage of spinlock semaphores is that they require busy waiting.
   (C) The solution to the dining-philosophers problem guarantees that no two neighbors are eating simultaneously also solves the deadlock problem.
   (D) A deadlock-free solution must eliminate the possibility of starvation.

7. For deadlock prevention, which necessary conditions would we try to remove?
   (A) mutual exclusion
   (B) hold and wait
   (C) no preemption
   (D) circular wait

8. Which are correct for memory management?
   (A) The algorithm best-fit is generally the fastest among three dynamic allocation strategies.
   (B) No fragmentation exists in a paging system.
   (C) We have one page table for each process using the inverted page table technique.
   (D) Segmentation is a memory-management scheme that supports the user view of memory.

9. Which are correct for page-replacement algorithms?
   (A) The FIFO page-replacement algorithm is a stack algorithm.
   (B) The optimal page-replacement algorithm is the best one and usually implemented in a commercial system.
   (C) The LFU and MFU page-replacement algorithms keep a counter of the number of references that have been made to each page.
   (D) The LRU page-replacement algorithm can be though as the optimal page-replacement one looking backward in time, rather than forward.

10. Which are correct for disk free-space management?
(A) The main advantage of the bit vector approach is its efficiency in finding the first free block.
(B) The linked-list approach is not efficient to traverse the list, which requires substantial I/O time.
(C) The grouping approach modifying the free-list one can find a large number of free blocks quickly.
(D) The counting approach is not good when space is allocated with the contiguous-allocation algorithm or through clustering.

題目11至題目20爲簡答題，每題5分。

11. Explain the difference between sharing a resource and multiplexing a resource.

12. Give the relative advantages and disadvantages of load time dynamic linking and run time dynamic linking.

13. Give two advantages of a DMA device controller over a non-DMA device controller.

14. What do real-time operating systems often use fixed scheduling?

15. What is the use of mounting?

16. What are the advantages and disadvantages of compressed files?

17. Explain the terms: race condition, atomic action and critical section.

18. Give an analogy between messages and semaphores.

19. Compare local and global page replacement. What are the advantages of each?

20. What are the main problems with the linked block method?

1. (10%) If an $n \times n$ matrix A, which has the property of $A = -A^T$; prove that $\det A = (-1)^n \det A$.

2. (10%) Let $B = \begin{bmatrix} aI & bI \\ cI & dI \end{bmatrix} = \left[\begin{array}{cccc:cccc} a & 0 & \cdots & 0 & b & 0 & \cdots & 0 \\ 0 & a & \cdots & 0 & 0 & b & \cdots & 0 \\ \vdots & \vdots & & \ddots & \vdots & \vdots & & \ddots \\ 0 & 0 & \cdots & a & 0 & 0 & \cdots & b \\ \hdashline c & 0 & \cdots & 0 & d & 0 & \cdots & 0 \\ 0 & c & \cdots & 0 & 0 & d & \cdots & 0 \\ \vdots & \vdots & & \ddots & \vdots & \vdots & & \ddots \\ 0 & 0 & \cdots & c & 0 & 0 & \cdots & d \end{array}\right]$, where I is a $m \times m$ sub-matrix;

   compute |B|.

3. (10%) Prove $\begin{vmatrix} 1 & 1 & 1 & \cdots & 1 \\ 1 & 2 & 2^2 & & 2^{(n-1)} \\ 1 & 3 & 3^2 & & 3^{(n-1)} \\ \vdots & & & & \\ 1 & n & n^2 & & n^{(n-1)} \end{vmatrix} = 1!2!3!\cdots(n-1)!$.

4. (10%) Find the distance of the point x = (1, 3, –2) of R^3 from the subspace W consisting of all vectors of the form $(a, 2a, 3a)$. Note that this is finding the distance of a point from a line.

5. (10%) The reachability matrix **R** of a digraph is defined as follows:

$$r_{ij} = \begin{cases} 1 & \text{if there is a path from vertex } P_i \text{ to } P_j \\ 1 & \text{if } i = j \\ 1 & \text{if there is no path from } P_i \text{ to } P_j \end{cases}$$

   Determine the reachability matrix of the digraph of a communication network, where its adjacency matrix is $\begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$.

國立雲林科技大學
97 學年度碩士班入學招生考試試題

系所：資工所
科目：線性代數

6. Let $T(\mathbf{x}) = \mathbf{A}\mathbf{x}$ be the linear transformation from $\mathbb{R}^2$ to $\mathbb{R}^2$ that reflects any vector onto the line L spanned by the vector $\begin{bmatrix} 4 \\ 3 \end{bmatrix}$.

   (a) Find the eigenvalues and their corresponding eigenvectors for the transformation matrix **A**. (10%)

   (b) Explain the physical meanings of the eigenvectors and eigenvalues for this linear transformation. Is this linear transformation invertible? Why? (10%)

   (c) Find the transformation matrix **B** of T by using a new basis that is the eigenvectors you found in (a). Show the matrices **A** and **B** are similar. (5%)

7. Given a transformation T from $\mathbb{R}^4$ to $\mathbb{R}^3$ defined by

$$T(\mathbf{x}) = \begin{bmatrix} x_1 + 2x_2 + 3x_3 + 4x_4 \\ x_1 + 3x_2 + 5x_3 + 7x_4 \\ x_1 - 3x_3 - 2x_4 \end{bmatrix} = \mathbf{A}\mathbf{x}$$

   (a) Find im(**A**) and ker(**A**), where im(**A**) and ker(**A**) are used to denote the image and the kernel of **A**, respectively. (10%)

   (b) Find the dimensions of im(**A**) and ker(**A**) that you found in (a). (5%)

8. Let $\mathbf{U} = \text{span}(\mathbf{x}_1, \mathbf{x}_2)$ where $\mathbf{x}_1 = [1 \quad -1 \quad 0 \quad 1]^T$ and $\mathbf{x}_2 = [1 \quad 0 \quad 1 \quad 0]^T$ in R^4.

   (a) Find an orthonormal basis for **U**. (5%)

   (b) If $\mathbf{x} = [2 \quad 1 \quad -1 \quad 1]^T$, express $\mathbf{x}$ as the sum of a vector in **U** and a vector in $\mathbf{U}^{\perp}$. (5%)

國立雲林科技大學
97學年度碩士班入學招生考試試題

系所：資工所
科目：計算機結構

1. (10 points) In the pipeline architecture, the control hazards can be solved by pipeline stall which is stalle one extra clock cycle before starting. If a program has 15% conditional branches instructions. Plea estimate the impact on the clock cycles per instruction (CPI) of stalling on branches. Assume all oth instructions have a CPI of 1.

2. (10 points) Identify all of the data dependencies in the following code. Which dependencies are data hazar that can be resolved via forwarding? Which dependencies are data hazards that will cause a stall?

```
add $3, $4, $2
add $5, $3, $1
lw  $6, 100($3)
add $7, $3, $6
```

3. (15 points) A computer system has 32 address lines and 32-Kbyte cache. Each cache block size is 32-byt For the following cases, how many tag-bit is required for each cache block? (15%)
   (a) A direct mapped cache
   (b) A fully associative cache
   (c) A 8-way set associative cache

4. (10 points) Suppose we have made the measurements of average CPI for instructions and average the instruction frequencies for gcc and spice, as shown in Table 1. Please compute the effective CPI.

Table 1

Instruction	Average CPI	gcc	spice
Arithmetic	1.0 clock cycles	48%	50%
Data Transfer	1.4 clock cycles	33%	41%
Conditional branch	1.7 clock cycles	17%	8%
Jump	1.2 clock cycles	2%	1%

5. (5 points) The performance of a 200 MHz microprocessor P is measured by execution 10,000,000 instructions of benchmark code, which is found to take 0.125 s. What is the value of CPI?

6. Consider two RAID disk systems that are meant to store 10 terabytes of data (not counting any redundancy) System *A* uses RAID 1 technology and System *B* uses RAID 5 technology with four disks in a "protectio group".

   (3 points) (a) How many more terabytes of storage are needed in System *A* than in System *B*?

   (3 points) (b) Suppose an application writes one block of data to the disk. If reading or writing a block takes 30 ms, how much times will the write take on System *A* in the worst case? How about on System *B* in the worst case?

   (4 points) (c) Is System *A* more reliable than System *B*? Why or Why not?

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97學年度碩士班入學招生考試試題

系所：資工所
科目：計算機結構

7. (5 points) (a) Find the average memory access time (AMAT) for a processor with a 2 ns clock, a miss penalty of 20 clock cycles, a miss rate of 0.05 misses per instruction, and a cache access time (including hit detection) of 1 clock cycle. Assume that the read and write miss penalties are the same and ignore other write stalls.

   (5 points) (b) (Continued Problem 2(a)) Suppose we can improve the miss rate to 0.03 misses per reference by doubling the cache size. This causes the cache access time to increase to 1.2 clock cycles. Using the AMAT as a metric, determine if this is a good trade-off.

8. (10 points) You are going to enhance a computer, and there are two possible improvements: either makes multiply instructions run four times faster than before, or make memory access instructions run two times faster than before. You repeatedly run a program that takes 100 seconds to execute. Of this time, 20% is used for multiplication, 50% for memory access instructions, and 30% for other tasks. What will the speedup be if you improve only multiplication? What will the speedup be if you improve only memory access? What will the speedup be if both improvements are made?

9. (5 points) (a) What is the hexadecimal representation for the IEEE 754 binary representation for the number $-20\frac{19}{32}$ in single precision?

   (7 points)(b)Perform $x + y$ with x = 0100 0110 1101 1000 0000 0000 0000 0000 and y = 1011 1110 1110 0000 0000 0000 0000 0000 representing single precision IEEE 754 floating-point numbers. What is the result in decimal?

10. (8 points) Translate each of the following problems from base ten notation into 2's complement notation (using patterns of 6 bits), and convert any subtraction problem to an equivalent addition problem, then perform the addition. Show your derivation in detail. (A)23+13 (B)-12-13