國立中山大學103學年度碩士暨碩士專班招生考試試題

科目名稱：計算機結構【資工系碩士班甲組、乙組】　　題號：434001

※本科目依簡章規定「不可以」使用計算機　　

1. (12%) Consider two different implementations of the same instruction set architecture. There are four classes of instructions, A, B, C, and D. The clock rate and CPI of each implementation are given in the following table.

		Clock Rate	CPI Class A	CPI Class B	CPI Class C	CPI Class D
(a)	P1	2.5 GHz	1	2	3	3
	P2	3 GHz	2	2	2	2
(b)	P1	2.5 GHz	2	1.5	2	1
	P2	3 GHz	1	2	1	1

(a) Given a program with 10^6 instructions divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D, which implementation is faster? (7%)

(b) What is the global CPI for each implementation? (5%)

2. (14%)

(a) $(520)_{10}$ = (　　)$_8$ = (　　)$_{16}$. (4%)

(b) Convert the decimal number –320 into signed 10-bit binary number in the 2's complement representation. (2%)

(c) Assume that signed numbers are stored in 10-bit words in 2's complement representation. What is the result of $(256)_{10} + (257)_{10}$? (4%)

(d) Show the IEEE 754 binary representation of the number $(-0.75)_{10}$ in single precision. (4%)

3. True or False Questions: (12%)

(2%) (a) A multi-core processor consists of multiple chips, each containing a processor.

(2%) (b)A server is a computer composed of hundreds to thousands of processors and terabytes of memory.

(2%) (c)Access time to random access memory (RAM) is longer than access time to hard disk.

(2%) (d)Assembly language consists of commands that processors understand.

(2%) (e)The application software is software/programs developed by the users.

(2%) (f)NaN in IEEE 754 can be the result of dividing 0 by 0 (0/0).

4. (10%)

Consider the segment of MIPS assembler code below.

```
lw $v1, 0($a0)
add $v2, $v2, $v1
sw $v2, 0($a1)
addi $a0, $a0, 1
```

(a) How many times is instruction memory accessed? How many times is data memory accessed? (Count only accesses to memory, not registers.) (6%, 3% each for two subproblems)

(b) What are the addressing modes used in the four instructions? (4%)

5. (14%)

The latency of a block of digital logic is the time needed to do the work in the block. Assume that logic blocks needed to implement a processor's datapath have the following latencies:

I-Mem	Add	Mux	ALU	Reg's	D-Mem	Sign-Extend	Shift-Left-2
200ps	70ps	20ps	90ps	90ps	250ps	15ps	10ps

Consider the following datapath using the above logic blocks.

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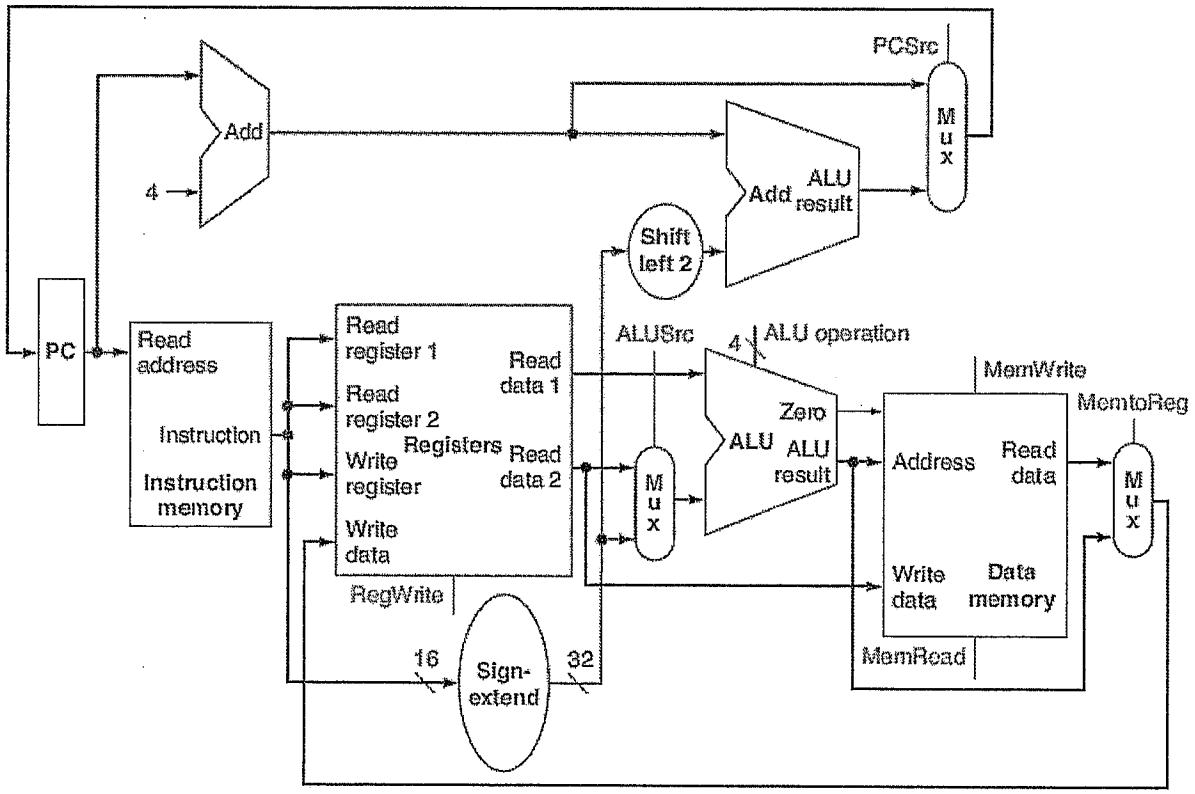

(a) What is the clock cycle time if the only types of instructions we need to support are ALU instructions (ADD, AND, etc.)? (5%)
(b) What is the clock cycle time if we only have to support LW (load word) instructions? (5%)
(c) What is the clock cycle time if we must support ALU, branch, load/store instructions? (4%)
(Hint: You need to find the overall latencies of the blocks in the longest path required to execute an instruction.)

6. (10%)
Let the above datapath be implemented with pipelining. Assume that individual stages of the datapath (Insrtuction Fetch, Instruction Decode, Execution, Memory access, Write Back) have the following latencies:

IF	ID	EXE	MEM	WB
250ps	350ps	150ps	300ps	200ps

(a) What is the clock cycle time in a pipelined and non-pipelined processor? (5%)
(b) What is the total latency of an LW instruction in a pipelined and non-pipelined processor? (5%)

7. (8%)
Assume that you are using a standard 5-stage pipelined processor (as shown in Problem 6) to execute the following MIPS instructions:

```
lw $1,40($6)
add $6,$2,$2
sw $6,50($1)
```

(a) Indicate dependences and their type. (4%)
(b) Assume there is no forwarding in this pipelined processor. Indicate hazards and add NOP instructions to eliminate them. (4%)

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8. (12%) Cache system
(a) Consider a direct-mapped cache with 16KB of data and 16-byte blocks, assuming a 32-bit

address. What is the length of the tag field? How many total bits are required, assuming a valid bit is used? (6%)

(b) Assume an instruction cache miss rate for gcc of 2% and a data cache miss rate of 4%. If a machine has a CPI of 2 without any memory stalls and the miss penalty is 40 cycles for all misses, determine how much faster a machine would run with a perfect cache that never missed. Assume 36% of instructions are loads/stores. (6%)

9. (8%) Briefly explain the following terms:
   (a) Page fault (4%)
   (b) Direct memory access (DMA) (4%)

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科目名稱：工程數學【資工系碩士班乙組】　　題號：434002

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1. (20%) Use Laplace Transform to solve the differential equation

$$y''+4y'+3y=e^{t};\quad y(0)=0,\ y'(0)=2.$$

2. (10%) The points $A(1,-2,1)$, $B(0,1,6)$ and $C(-3,4,-2)$ form the vertices of a triangle. Calculate the angle between the line $\overline{AB}$ and the line from A to the midpoint P of $\overline{BC}$. You do not need to give the explicit value of the angle. Just express the angle using inverse trigonometric functions. Hint: use dot product for two vectors $\overrightarrow{AB}$ and $\overrightarrow{AP}$ which is a scalar equal to the multiplication of the lengths of the two vectors and the cosine of the angle between the two vectors.

3. (10%) Find the plane containing the points $A(1,2,1)$, $B(-1,1,3)$ and $C(-2,-2,-2)$. Hint: the cross product of two vectors $\overrightarrow{AB}$ and $\overrightarrow{AC}$ is another vector that is orthogonal to the two vectors.

4. (30%) Let matrix $A=\begin{bmatrix}0 & 0 & -2\\ 1 & 2 & 1\\ 1 & 0 & 3\end{bmatrix}$.

   4.1 (10%) Find the eigenvalues and the corresponding eigenvectors of the matrix A.

   4.2. (10%) Find matrix P that makes matrix A diagonal, that is, $D=P^{-1}AP$ where D is a diagonal matrix.

   4.3 (10%) Find the n-th power of matrix A, that is, A^{n}. It is not necessary to explicitly compute P^{-1}. You can just express the result in terms of P and P^{-1}.

5. (20%) Let matrix $A=\begin{bmatrix}1 & 0 & 0\\ 1 & 1 & 0\\ 1 & 1 & 1\end{bmatrix}$ that is composed of three column vectors $a_1=\begin{bmatrix}1\\1\\1\end{bmatrix}, a_2=\begin{bmatrix}0\\1\\1\end{bmatrix}, a_3=\begin{bmatrix}0\\0\\1\end{bmatrix}$.

   Find the QR-decomposition of A, i.e., $A=QR$ where Q is a 3×3 matrix with orthonormal column vectors and R is a 3×3 invertible upper triangular matrix. Hint: use Gram-Schmidt process to transform the basis vectors of the three column vectors in A into an orthogonal basis, and then normalize the orthogonal basis vectors to obtain an orthonormal basis corresponding to the column vectors q_1, q_2, q_3 in matrix Q. The entry r_{ij} of matrix R is the inner product of vectors a_i and q_j.

6. (10%) Let function $f(x)$ be defined for $-L\le x\le L$. The Fourier series of $f(x)$ is

$$f(x)=\frac{1}{2}a_0+\sum_{n=1}^{\infty}a_n\cos\left(\frac{n\pi x}{L}\right)+\sum_{n=1}^{\infty}b_n\sin\left(\frac{n\pi x}{L}\right).$$

   Find the coefficients of the Fourier series for the function $f(x)=x, -\pi\le x\le\pi$.

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科目名稱：作業系統與資料結構【資工系碩士班甲組】　　題號：434003

※本科目依簡章規定「不可以」使用計算機　　

INSTRUCTIONS: If any question is unclear or you believe some assumptions need to be made, state your assumptions clearly at the beginning of your answer.

1. (10%) A computer has six tape drives, with *n* processes competing for them. Each process may need two drives. For which values of *n* is the system deadlock free?

2. (10%) Consider the two-dimensional array A:

```
double A[][] = new double[200][200];
```

where each double occupies 8 bytes and A[0][0] is at location 200, in a paged system with pages of size 200 bytes. A small process is in page 0 (locations 0 to 199) for manipulating the matrix; thus, every instruction fetch will be from page 0. For three page frames, how many page faults are generated by the following array initialization loops, using LRU replacement and assuming (1) page frame 0 has the process in it, (2) the other two are initially empty, and (3) the array is stored in memory column-major?

(a) (5%)
```
for (int i = 0; i < 200; i++)
    for (int j = 0; j < 200; j++)
        A[i][j] = 0;
```

(b) (5%)
```
for (int j = 0; j < 200; j++)
    for (int i = 0; i < 200; i++)
        A[i][j] = 0;
```

3. (10%) Assume a page reference string for a process with *m* frames (initially all empty). The page reference string has length *n* with *p* distinct page numbers occurring in it. For any page-replacement algorithms,

(a) (5%) What is a lower bound on the number of page faults?
(b) (5%) What is an upper bound on the number of page faults?

4. (10%) Given a UNIX *i*-node with ten direct blocks and three levels of indirect blocks (i.e., a single, a double, and a triple) and assuming that the sizes of a pointer and a block are, respectively, 8 bytes and 8 Kbytes, answer the following questions.

(a) (5%) What would be the size of the smallest file allowed in bytes?
(b) (5%) What would be the size of the largest file allowed in bytes?

5. (10%) A disk has 10000 cylinders, each with 10 tracks of 512 blocks. A seek takes 1 ms per cylinder moved. If no attempt is made to put the blocks of a file close to each other, two blocks that are logically consecutive (i.e., follow one another in the file) will require an average seek, which takes 6 ms. If, however, the operating system makes an attempt to cluster related blocks, the mean interblock distance can be reduced to 2 cylinders and the seek time reduced to 200 μs. Assuming that the rotational latency is 3 ms and the transfer time is 10 μs per block, answer the following questions.

(a) (5%) How long does it take to read a 200 block randomly placed file?
(b) (5%) How long does it take to read a 200 block clustered file?

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6. Red-Black Tree (10%):

(1) (4%) A red-black tree is a binary search tree where every node is either red or black. What are the four properties of a red-black tree?

(2) (3%) Suppose that a red-black tree contains *n* internal nodes. What is its maximum height? What is the time to search one value? What is the time to find the maximum value?

(3) (3%) Do you think whether a red-black tree is balanced or not? Please give your reason.

7. Tree Search & Expression Tree (10%):

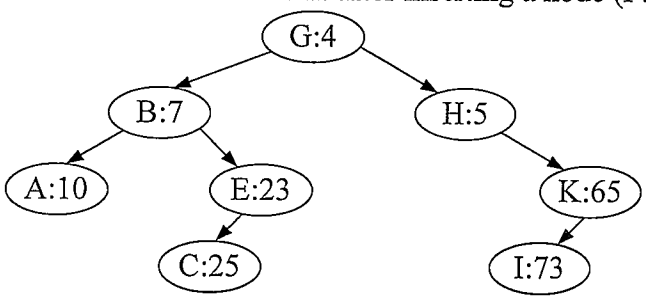
(1) (6%) Suppose that each internal node of a tree has at most three children. Given the BFS sequence "iceodlmfhjbgna" and the DFS sequence "icdbglemnofhaj" of the tree, please draw that tree.

(2) (4%) Given a postfix expression "8 3 2 + - 4 9 3 / + * 3 * 7 +", please translate it into an infix expression and give the calculation result.

8. Treap (10%):

(1) (5%) Given the following treap, please show the final result after inserting a node (D:9).

(2) (5%) Following (1), please show the final result after inserting a node (F:2).



9. Hash Functions (10%):

(1) (4%) What are the two major characteristics of hash functions to make them be widely adopted in authentication applications?

(2) (4%) What is a hash collision? How can you solve this problem by chaining?

(3) (2%) What is a perfect hashing?

10. Heaps (10%):

(1) (2%) What is a binomial heap?

(2) (4%) Please explain the two binomial-heap properties.

(3) (2%) Suppose that two binomial heap H_1 and H_2 have n_1 and n_2 nodes, respectively. Then, what is the worst-case running time to unite H_1 and H_2?

(4) (2%) What is a Fibonacci heap?

國立中山大學 103 學年度碩士暨碩士專班招生考試試題

科目名稱：離散數學【資工系碩士班甲組】　　題號：434004

※本科目依簡章規定「不可以」使用計算機　　

There are 8 problems in this test. Note that you should write down detailed steps for the solution to each problem; otherwise, no credits for that problem will be given.

1. [10%] (a) [2%] What is the Well-Ordering Principle? (b) [2%] What is the Principle of Mathematical Induction? (c) [6%] Please use the Well-Ordering Principle to prove that the Principle of Mathematical Induction is true?

2. [15%] Let $X = \{x_1, x_2, \ldots, x_m\}$ and $Y = \{y_1, y_2, \ldots, y_n\}$ with $|X| = m$ and $|Y| = n$.
   (a) [3%] How many functions $f: X \to Y$ satisfy $f(x_1) = f(x_m) = y_n$?
   (b) [3%] Let $m \le n$. How many functions $f: X \to Y$ are one-to-one?
   (c) [3%] Let $m = n$. How many bijective functions $f: X \to Y$ satisfy $f(x_1) \neq y_1$?
   (d) [3%] How many relations are there from X to Y ?
   (e) [3%] How many relations R from X to Y satisfy $x_1 R y_1$ and $x_2 R y_2$?

3. [15%] Solve the following recurrence relations:
   (a) [5%] $a_n + 3a_{n-1} + 2a_{n-2} = 0$, $n \ge 2$, $a_0 = 1$, $a_1 = 4$
   (b) [5%] $a_n - 10a_{n-1} + 25a_{n-2} = 0$, $n \ge 2$, $a_0 = 1$, $a_1 = 0$
   (c) [5%] $3a_n + 5a_{n-1} + 2a_{n-2} = 10n + 11$, $n \ge 2$, $a_0 = 10$, $a_1 = -10/3$

4. [10%] Let $I = \{0, 1\}$ be the input alphabet and $O = \{0, 1\}$ be the output aplphabet of a finite state machine that recognizes all strings in the language $\{0, 1\}^*\{01\}\{0, 1\}^+$. Please draw a state diagram for the finite state machine after minimization.

5. [12%] Find the coefficient of x^n in each of the following formulas:
   (a) [2%] $(2+3x)^{1000}$; (b) [4%] $(x^7 + x^8 + x^9 + \ldots)^9$; (c) [6%] $\dfrac{4}{x^2 - 8x + 15}$.

6. [8%] Consider the number of the partitions of a positive integer into positive summands without regard to order. For example, 4 = 1+1+1+1 = 1+1+2 = 2+2 = 1+3, so the integer 4 has five partitions. Find the generating function for the number of the partitions of a positive integer n into positive summands where each summand appears at most twice in each of the partitions. Please express your generating function in a closed form and indicate how to find the number of the partitions of n from your generating function.

7. [10%] Please compute $w = (995^{1010} \bmod 97)$, $x = (3866^{2402} \bmod 385)$, and $y = ((w - x) \bmod 17)$, and then output (w, x, y).

8. [20%] Let p and q be two distinct prime numbers and $n = p*q$ be the product of p and q. For any u_1, u_2 in $\mathbf{Z}_p^*$ and any v_1, v_2 in $\mathbf{Z}_q^*$, define $(u_1, v_1) * (u_2, v_2) = (u_1 * u_2 \bmod p, v_1 * v_2 \bmod q)$. (a) [5%] Please show that $(\mathbf{Z}_p^* \times \mathbf{Z}_q^*, *)$ is a commutative group. (b) [15%] Prove that $(\mathbf{Z}_p^* \times \mathbf{Z}_q^*, *)$ is isomorphic to $(\mathbf{Z}_n^*, *)$.