國立中山大學106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(問答申論題)　　

NOTE: If some questions are unclear or not well defined to you, you can make your own assumptions and state them clearly in the answer sheet.

1. (5% total) True or False. (If the statement is false, please explain the answer shortly)
   ____ 1.1 (1%) Increasing the block size of a cache is likely to take advantage of temporal locality.
   ____ 1.2 (1%) Increasing the page size tends to decrease the size of the page table.
   ____ 1.3 (1%) Virtual memory typically uses a write-back strategy, rather than a write-through strategy.
   ____ 1.4 (1%) If the cycle time and the CPI both increase by 10% and the number of instruction decreases by 20%, then the execution time will remain the same.
   ____ 1.5 (1%) In uniform memory access (UMA) designs, all processors use the same address space.

2. (10% total) Server farms such as Google and Yahoo! Provide enough computer capacity for the highest request rate of the day. Imaging that most of the time these servers operate at only 60% capacity. Assume further that the power does not scale linearly with the load; that is, when the servers are operating at 60% capacity, they consume 90% of maximum power. The servers could be turned off, but they would too long to restart in response to more load. As new system has been proposed that allows for a quick restart but requires 20% of the maximum power while in this "barely alive" state.
   2.1 (5%) How much power saving would be achieved by turning off 60% of the servers?
   2.2 (5%) How much power saving would be achieved by placing 60% of the servers in the "barely alive state?

3. (20% total) A multicycle CPU has three implementations. The first one is a 5-cycle IF-ID-EX-MEM-WB design running at 4.8GHz, where load takes 5 cycles; store/R-type 4 cycles and branch/jump 3 cycles. The second one is a 6-cycle design running 5.6GHz, with MEM replaced by MEM1 and MEM2. The third is a 7-cycle design running at 6.4GHz, with IF further replaced by IF1 and IF2. Assume we have an instruction mix: load 26%, store 10%, R-type 49%, branch/jump 15%.
   3.1 (10%) Do you think it is worthwhile to go for the 6-cycle design over the 5-cycle design?
   3.2 (10%) How about the 7-cycle design over the 6-cycle design, is it worthwhile?

4. (15% total) Identify all of the data dependencies in the following code running in a 5-stage pipelined MIPS CPU. Which dependencies are data hazards that will be resolves via forwarding? Which dependencies are data hazards that will cause a stall?

Line	Instructions
1	add $3 $4 $2
2	sub $5 $3 S1
3	lw $6 200($3)
4	add $7 $3 $6

5. (10% total) For a system with 32-bit address, the CPU uses a 4-way set associate cache with block size of 16 bytes. The cases has 1024 entries in total
   5.1 (5%) Determine the tag size for each block.
   5.2 (5%) Assume each block requires 2 extra valid bits. What is the size of the cache memory?

背面有題

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6. (20% total) Given the following datapath for the single-cycle implementation of a computer and the definition of its instructions:

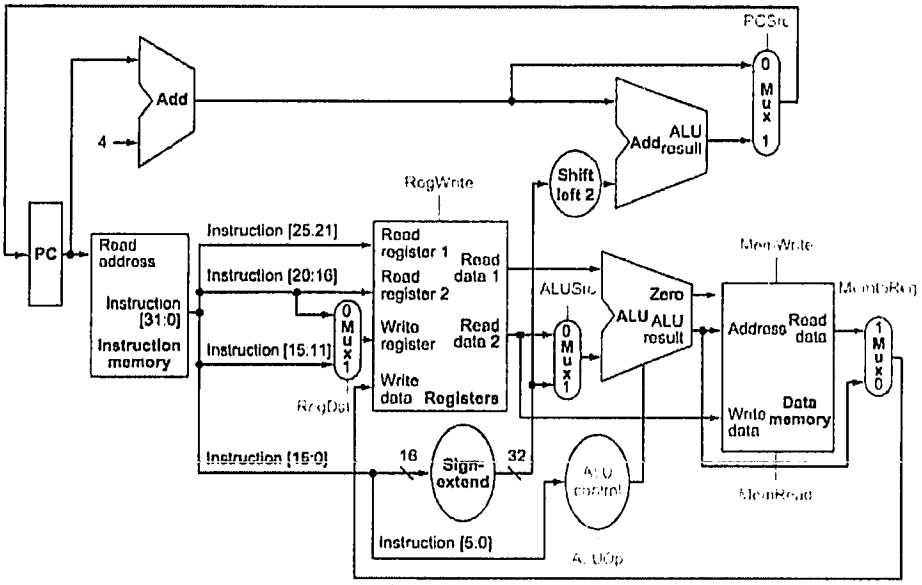

Figure 1.

add $rd $rs $rt
lw $rt addr($rs)
sw $rt addr($rs)
beq $rs $rt addr

Assume that the instructions are fixed length and the operation time for the major functional units in this implementation are as follows:

- Memory units: 2ns
- ALU and adders: 2ns
- Register file (read or write): 1ns
- Multiplexers, control unit, PC accesses, sign extension unit, and wires: no delay

Please compute the required time for each instruction and explain why.

7. (10% total) The following series of branch outcomes occurs for a single branch in a program. T means the branch is taken; N means the branch is not taken.
T T T N N T T T
How many instances of this branch instruction are mis-predicted with a 1-bit and 2-bit local branch predictor, respectively? Assume the Branch History Table (BHT) are initialized to the N state. You may assume that this is the only one branch in this program.

8. (10% total) A computer whose processes have 1024 pages in their address spaces keeps its page tables in memory. The overhead required for reading a word from the page table is 500 ns. In order to reduce the overhead, the computer has Translation Lookaside Buffer(TLB), which holds 32 (virtual page, physical page frame) pairs, and can do a look up in 100 ns. What hit rate is needed to reduce the mean overhead to 200 ns?

國立中山大學106學年度碩士暨碩士專班招生考試試題

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(問答申論題)　　

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%) What would be the output of the following C program that uses the Pthreads API? (*Note that the line numbers are for reference only.*)

```
 1 #include <stdio.h>
 2 #include <stdlib.h>
 3 #include <unistd.h>
 4 #include <pthread.h>
 5 #include <sys/types.h>
 6 #include <sys/wait.h>
 7
 8 static void *runner(void *param)
 9 {
10     (* (int*) param)--;
11     pthread_exit(0);
12 }
13
14 int main(int argc, char **argv)
15 {
16     int value = 101;
17     pid_t pid = fork();
18     if (pid > 0) {
19         int status;
20         waitpid(-1, &status, 0);
21         printf("A = %d\n", --value);
22     }
23     else if (pid == 0) {
24         pid_t pid = fork();
25         if (pid > 0) {
26             int status;
27             waitpid(-1, &status, 0);
28             printf("B = %d\n", value--);
29         }
30         else if (pid == 0) {
31             pid_t pid = fork();
32             pthread_t tid;
33             pthread_create(&tid, NULL, runner, &value);
34             pthread_join(tid, NULL);
35             if (pid > 0) {
36                 int status;
37                 waitpid(-1, &status, 0);
38                 printf("C = %d\n", ++value);
39             }
40             else {
41                 printf("D = %d\n", value++);
42             }
43         }
44         else {
45             return 1;
46         }
47     }
48     else {
49         return 1;
50     }
51     return 0;
52 }
```

背面有題

國立中山大學106學年度碩士暨碩士專班招生考試試題

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2. (10%; 5% each) 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) What is an upper bound on the number of page faults?

   (b) What is a lower bound on the number of page faults?

3. (10%) A computer whose processes have 2048 pages in their address spaces keeps its page tables in memory. The overhead required for reading a word from the page table is 600 nsec. To reduce this overhead, the computer has a TLB, which holds 64 (page, frame) pairs and can do a lookup in 100 nsec. What hit rate is needed to reduce the mean overhead to 200 nsec or less?

4. (10%; 5% each) 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) What would be the size of the smallest file allowed in bytes?

   (b) What would be the size of the largest file allowed in bytes?

5. (10%; 5% each) A disk has 24000 cylinders, each with 16 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) How long does it take to read a 300 block randomly placed file?

   (b) How long does it take to read a 300 block clustered file?

6. (10%) *Declare* in a single statement in C a pointer "p" to the array "`int a[256];`" so that `p[1]` is an alias of `a[0]`, `p[2]` is an alias of `a[1]`, and so on, all the way up so that `p[256]` is an alias of `a[255]`.

7. (10%) The Ackermann function $A(m, n)$ is defined recursively for non-negative integers m and n as follows:

$$A(m,n) = \begin{cases} n+1 & \text{if } m = 0, \\ A(m-1,1) & \text{if } m > 0 \text{ and } n = 0, \\ A(m-1, A(m, n-1)) & \text{if } m > 0 \text{ and } n > 0. \end{cases}$$

   Its value grows very quickly, even for small values of m and n. For instance, $A(1,1) = 65533$. What would be the value of $A(2,3)$?

8. (10%) Assuming $n = 2^m$, write out the closed form solution for the recurrence relation

$$T(n) = \begin{cases} 1 & \text{for } n = 2, \\ 2T(n/2) + 2 & \text{for } n > 2. \end{cases}$$

國立中山大學106學年度碩士暨碩士專班招生考試試題

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(問答申論題)　　

9. (10%) Analyze the behavior of QUICKSORT in the case where a schizophrenic adversary picks the best possible splitter (partitioning element) instead of the worst, every other time (i.e., he alternates between best and worst). What running time is induced by this "adversary?"

10. (10%) Transform the following expression to prefix and postfix.

$$(A+B)*(C+D-E)*F$$

國立中山大學106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(問答申論題)　　共1頁第1頁

There are 7 problems in this test. No calculators are allowed. Write down detailed steps for the solution to each problem. Otherwise, no credits for that problem will be given.

1. (10) Let $x_1, x_2, \ldots, x_n$ be a sequence of n integers. A consecutive subsequence of $x_1, x_2, \ldots, x_n$ is a subsequence $x_i, x_{i+1}, \ldots, x_j$ for some i, j, $1 \leq i \leq j \leq n$. Show that for any k, $1 \leq k \leq n$, there is a consecutive subsequence whose sum is divisible by k.

2. (10) Assume that a sequence of numbers is defined by $x_0 = 0$, $x_1 = 1$, and $x_n + 2x_{n-1} = 15x_{n-2}$ for $n > 1$. Find generating function for the sequence, and then find an explicit expression for x_n.

3. (10) Show that $\binom{n}{k} = \binom{n-1}{k} + \binom{n-1}{k-1}$. Give combinatorial explanation to the equation.

4. (30) A *bipartite graph* is a graph whose vertices can be partitioned into two subsets X and Y so that each edge has one end in X and the other end in Y. A *cycle* of G is a sequence of vertices $v_0, v_1, \ldots, v_l$ such that each vertex v_i is distinct, except $v_0 = v_l$, and v_{i-1} and v_i are adjacent for each $i = 1, 2, \ldots, l$. The *length of the cycle* is l. A *k-cube* is a graph whose vertices are binary strings of length k, for some integer $k > 0$. Two vertices are adjacent if and only if they differ in exactly one bit.

   (a) Show that every k-cube is bipartite by partitioning its vertexes into X and Y, and then show that every edge connects some vertex in X and another vertex in Y. (10)

   (b) Show that a bipartite graph has no cycles of odd length. (10)

   (c) Show that if a graph has no cycles of odd length then it is bipartite. (10)

5. (10) Suppose that 5 points are chosen in a square whose sides have length 2. Show that there must be at least two points p and q such that the distance between them is no more than $\sqrt{2}$.

6. (10) Fibonacci numbers are defined as $f_0 = 0$, $f_1 = 1$ and $f_n = f_{n-1} + f_{n-2}$ for $n > 1$. Show that f_{3k} is even, for every positive integer k.

7. (20) Let m and n be two positive integers, $m \leq n$. Define $\binom{n}{m} = \dfrac{n!}{m!(n-m)!}$.

   (a) Show that if n is prime, then n divides $\binom{n}{i}$ for every i, $1 \leq i < n$. (10)

   (b) Show that if n is composite, then n does not divide $\binom{n}{i}$ for some i, $1 \leq i < n$. (10)

國立中山大學106學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【資工系碩士班乙組】　　題號：434002

※本科目依簡章規定「不可以」使用計算機(問答申論題)　　

1. (16%) If A is an $n \times n$ matrix, then A is called **idempotent** if $A^2 = A$. Let A and B be $n \times n$ idempotent matrices.

1.1 (4%) Show that AB is idempotent if $AB = BA$.

1.2 (4%) Show that if A is idempotent, then A^T is idempotent.

1.3 (4%) Is $A+B$ idempotent? Justify your answer.

1.4 (4%) Find all values of k for which kA is also idempotent.

2. (16%) A periodic signal $x(t)$ with a period $T_0 = 10$, $0 \le t \le 10$ by the equation $x(t) = \begin{cases} 0 & 0 \le t \le 5 \\ 2 & 5 < t \le 10 \end{cases}$

2.1 (4%) Sketch the periodic function $x(t)$ over the time interval $-10 \le t \le 20$.

2.2 (4%) Determine the DC coefficient of the Fourier series, a_0.

2.3 (4%) Use the Fourier analysis integral to find a_1, the first Fourier series coefficient.

2.4 (4%) If we add a constant value of one to $x(t)$, we obtain the signal $y(t) = 1 + x(t)$ with $y(t)$ given over one period by $y(t) = \begin{cases} 1 & 0 \le t \le 5 \\ 3 & 5 < t \le 10 \end{cases}$.

The signal can be represented by a Fourier series, but with different coefficients: $y(t) = \sum_{k=-\infty}^{\infty} b_k e^{jk\omega_0 t}$.

Explain how b_0 and b_1 are related to a_0 and a_1. Note: you should not have to evaluate any new integrals explicitly to answer this question.

3. (18%) The matrix is $A = \begin{bmatrix} 2 & 1 & 2 \\ 2 & 2 & -2 \\ 3 & 1 & 1 \end{bmatrix}$

3.1 (3%) Find the characteristic polynomial.

3.2 (6%) Find the eigenvalues,

3.3 (9%) And Find the associated eigenvectors.

4. (20%) Using Laplace transform and showing the details of your work, solve the initial value problem.

$$y_1' = -2y_1 + 3y_2, \quad y_2' = 4y_1 - y_2, \quad y_1(0) = 4, \quad y_2(0) = 3,$$

5. (14%) Find the general solution of the following differential equation.

$$y'' + 4y' + 4y = e^{-2x} \sin 2x$$

6. (16%) Solve the following initial value problem.

$$y''' - 2y'' + 4y' - 8y = 0, \; y(0) = -1, \quad y'(0) = 30, \quad y''(0) = 28,$$