國立中山大學 113 學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：離散數學【資工系碩士班甲組】

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*There are 10 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%] In how many ways can we distribute nine identical white balls into three distinct buckets so that the third bucket has an even number of balls in it?

2. [10%] Among the 800 three-digital integers (from 200 to 999) those such as $222, 363, 505, 989$, where the integer is the same whether it is read from left to right or from right to left, are called palindromes. Without actually determining all of these three-digital palindromes, what is the sum of them?

3. [10%] Prove that the number of primes is infinite.

4. [10%] If we can guarantee that a and b are relatively prime, there exists an inverse of a under modulo b as a^{-1} (mod b). How can we find out a^{-1} using Euclidean algorithm? (Hint: If c is the greatest common divisor of a and b, there exists a linear equation, $\exists x, y$ such that $ax + by = c$.)

5. [10%] How many three-factor unordered factorizations, where each factor is greater than 1, are there for 389,298?

6. Each of the following functions $f: \mathbb{Z} \times \mathbb{Z} \to \mathbb{Z}$ is a closed binary operation on $\mathbb{Z}$. Determine in each case whether f is commutative and/or associative?
   (a) [5%] $f(x, y) = 7x + 17y - 119xy$
   (b) [5%] $f(x, y) = x^{3x+7} + y$

7. Let $A = \{3, 5, 9, 11, 13, 17\}$. How many symmetric relations on A contain exactly
   (a) [5%] three ordered pairs?
   (b) [5%] six ordered pairs?

8. [10%] In how many ways can 2800 identical books be divided, in packages of 50, among 5 student groups so that each group get at least 200, but not more than 600 of the books?

9. [10%] Solve the recurrence relation, $a_{n+2} + a_n = 0, n \ge 0, a_0 = 1, a_1 = 5$.

10. [10%] Solve the recurrence relation, $a_{n+2} - 8a_{n+1} + 15a_n = 0, n \ge 0, a_0 = 1, a_1 = 6$ by the method of generating functions.

國立中山大學 113 學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：作業系統與資料結構【資工系碩士班甲組】

NSTRUCTIONS: 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. What is printed by each of the following C program?

   (a) (5%)
   ```c
   int d=48;
   printf("%d \n", (d&(-d+1)) + 3); // &: bitwise AND;
   ```

   (b) (10%)
   ```c
   int x[ ]={ 8, 5, 3, 9, 7, 4, 6, 2};
   int max(int left, int right) {
       int mid=(int) (left+right)/2;        // e.g. 7/2=3, 6/2=3
       int b;
       if (left==right)
           b=x[mid];
       else {
           int c=max(left, mid);
           if (c > max(mid+1, right))
               b=c;
           else
               b=max(mid+1, right);
       }
       cout << b << endl;
       return b;
   }
   int main( ) {
       max(1,5);
   }
   ```

2. (10%) A two-dimensional array N stores the nonnegative integers with the style shown in the following table. For example, $N[0][0]=0$, then $N[0][1] = 3$, $N[0][2] = 4$, $N[1][0]=2$, and so on. Please present a formula for the value stored in $N[i][j]$, expressed in terms of i and j.

0	3	4 .	15	16	...
1	2	5	14	17	...
8	7	6	13	18	...
9	10	11	12	19	...
24	23	22	21	20	...
...	...	...	...	...	...

3. (10%) Please indicate whether each of the following sorting algorithms is a stable sort or not: bubble sort, heap sort, quick sort, merge sort, radix sort.

4. A large block with a height of 2 units and a width of m units, denoted by $2 \times m$, can be decomposed into small pieces of two possible types: L-shape (with three units) and square (with one unit). For example, a block of 2×1 has only one decomposition method, which is decomposed into two squares. A block of 2×2 has five decomposition methods, as shown in the following figure. Let $d(m)$ represent
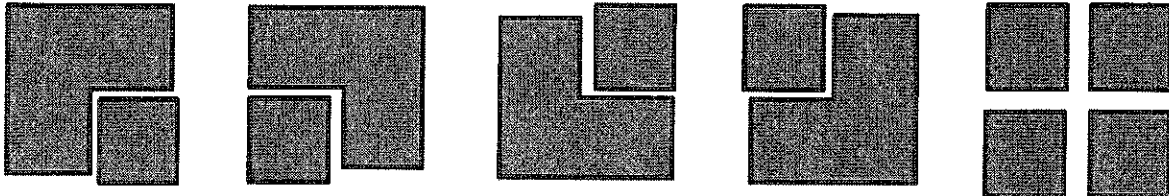
the number of decomposition methods for a block of $2 \times m$, $m \geq 0$. For initialization, we have $d(1)=1$ and $d(2)=5$. We also assume that $d(0)=1$.

(a) (5%) What is the value of $d(3)$?

(b) (10%) We can express $d(m)$ with a recurrence formula: $d(m) = a \times d(m\text{-}1) + b \times d(m\text{-}2) + c \times d(m\text{-}3)$, for $m \geq 4$. What are the values of a, b and c?

5. (a) (6%) Explain the three methods to translate addresses in a real-time system.

    (b) (4%) What is the difference between non-maskable and maskable interrupts?

6. (a) (6%) Given five processes arriving at time 0, processes P1, P2, P3, P4, and P5 have burst times of 10, 1, 2, 1, and 5 and are assigned with priority of 3, 1, 3, 4, and 2, respectively. A smaller priority number indicates a higher priority. Calculate the average waiting time of processes using the round-robin (with quantum = 1), the shortest job first, and the non-preemptive priority scheduling schemes.

    (b) (4%) Suppose that the memory access time is 150 nanoseconds and the average page fault time is 60,000 nanoseconds. What is the expected page fault rate to keep the effective access time for demand paging lower than 175 nanoseconds?
    [Note] *You need to list the calculation in your answer; otherwise, no points will be awarded.*

7. (10%) For each transaction T_i in the system, we associate a unique timestamp $TS(T_i)$. Each data item Q is also associated with two timestamp values: 1) W-timestamp(Q) is the largest timestamp of any transaction that successfully executed write(Q); and 2) R-timestamp(Q) denotes the largest timestamp of any transaction that successfully executed read(Q). Please show how the timestamp ordering protocol operates to check if a non-serial schedule is conflict serializable.
    [Hint] *You can show how this protocol operates when transaction T_i issues read (Q) and write (Q).*

8. (20%) Fill-in questions (2 points each)
    (a) Each thread has a _____ to indicate the address of the next instruction to be executed.
    (b) Any solution to the critical-section problem has to meet three requirements, including mutual exclusion, progress, and _____.
    (c) A _____ buffer can be viewed as a cache for a page table.
    (d) The _____ unit can map logical pages to physical page frames in memory.
    (e) _____ means that a process is spending more time paging than executing.
    (f) Any entity containing a file system is generally known as a _____.
    (g) RAID level 6 employs the _____ redundancy scheme.
    (h) In role-based access control, a _____ is the right to execute a system call or to use an option within that system call.
    (i) AES can use key lengths of 128, _____, and 256 bits and works on 128-bit blocks.
    (j) A _____ virus attempts to avoid detection by modifying parts of the system that could be used to detect it.

國立中山大學 113 學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學【資工系碩士班乙組】

1.(15%) Let A denote the matrix. Find the eigenvalues for A.

$$A = \begin{bmatrix} 1 & 0 & -2 \\ 0 & 5 & 0 \\ -2 & 0 & 4 \end{bmatrix}$$

2. (15%) Let B denote the matrix. Compute the inverse matrix of B.

$$B = \begin{bmatrix} -4 & 0 & 5 \\ -3 & 3 & 5 \\ -1 & 2 & 2 \end{bmatrix}$$

3.(15%) Solve $x'' + x = sin2t$ with $x(0) = 2,\ x'(0) = 1$ by the Laplace transform method.

4. (15%) Solve $x' + 2x = e^{-t}$ with $x(0) = \dfrac{3}{4}$.

5. (20%)A periodic waveform $x(t)$ with period T=4 is defined over one period by the equation
$x(t) = e^{-t} \quad 0 \le t < 4$
5.1 (10%) Carefully sketch $x(t)$.
5.2 (10%) Determine the Fourier series coefficient, a_k, for the above waveform $x(t)$. Give a general formula valid for any integer k.

6. (20%) Find the general solution of the following equations:
$y_1' = y_1 + y_2 + 5cost$
$y_2' = 3y_1 - y_2 - 5sint$

國立中山大學113學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：計算機結構【資工系碩士班甲組、乙組】

一作答注意事項一

考試時間：100分鐘

● **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。

● **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答。

● 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。

● 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。

● 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。

● 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。

● 試題採雙面列印，考生應注意試題頁數確實作答。

● 違規者依本校招生考試試場規則及違規處理辦法處理。

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. (8% total) When parallelizing an application, the ideal speedup is speeding up by the number of processors. This is limited by two things: percentage of the application that can be parallelized and the cost of communication. If 80% of the application is parallelizable, answer the following questions.

1.1 (4%) What is the speedup with 8 processors, ignoring the cost of communication?

1.2 (4%) What is the speedup with 8 processors if, for every time the number of processors is doubled, the communication overhead is increased by 0.5% of the original execution time?

2. (8% total) Assume a hypothetical GPU with the following characteristics:
   - Clock rate 2.0 GHz
   - Contains 16 SIMD processors, each containing 16 single-precision floating-point units
   - Has 600 GB/sec off-chip memory bandwidth

2.1 (4%) Without considering memory bandwidth, what is the peak single-precision floating-point throughput for this GPU in GFLOPS/sec, assuming that all memory latencies can be hidden?

2.2 (4%) Is this throughput sustainable given the memory bandwidth limitation? Please explain your reasons clearly.

3. (18% total) Assume that individual stages of the datapath have the following latencies, and instructions executed by the processor are broken down as the following percentages:

IF	ID	EX	MEM	WB	alu	beq	lw	sw
250 ps	150 ps	350 ps	300 ps	200 ps	45%	10%	25%	20%

3.1 (4%) What is the clock cycle time in a non-pipelined and pipelined processor, respectively?

3.2 (4%) What is the individual total latency of the following two instructions: **lw, beq** in a non-pipelined and pipelined processor?

3.3 (6%) Assuming there are no stalls or hazards, what is the total execution time of the following four instructions: **lw, sw, add, beq** in a non-pipelined and pipelined processor, respectively?

3.4 (4%) Assuming there are no stalls or hazards, what is the utilization of the data memory and the write-register port of the "Register" unit?

4. (15% total) The importance of having a good branch predictor depends on how often conditional branches are executed. Together with branch predictor accuracy, this will determine how much time is spent stalling due to mispredicted branches. Assume that the breakdown of dynamic instructions into various instruction categories is as follows:

R-Type	BEQ	JMP	LW	SW
40%	20%	5%	25%	10%

Also, assume the following branch predictor accuracies:

Always-Taken	Always-Not-Taken	2-Bit
40%	60%	80%

4.1 (5%) Assume no stall cycle is required when branch prediction is correct. Stall cycles due to mispredicted branches increase the CPI. What is the extra CPI due to mispredicted branches with the always-taken predictor? Assume that branch outcomes are determined in the EX stage of a basic 5-stage pipelined processor, that there are no data hazards, and that no delay slots are used.

4.2 (5%) Repeat 4.1 for the 2-bit predictor.

4.3 (5%) With the always-taken predictor, what speedup would be achieved if we could convert half of the branch instructions in a way that replaces a branch instruction with an ALU instruction? Assume that correctly and incorrectly predicted instructions have the same chance of being replaced.

5. (15% total) Caches are important to providing a high-performance memory hierarchy to processors. Below is a list of 32-bit memory address references, given as word addresses.
   3, 180, 43, 2, 191, 88, 190, 14, 181, 44, 186, 253

5.1 (9%) For each of these references, identify the binary address, the tag, and the index given a direct-mapped cache with two-word blocks and a total size of 8 blocks. Also list if each reference is a hit or a miss, assuming the cache is initially empty.

Word Address	Binary Address	Tag	Index	Hit/Miss
3	0000 0011	0	3	Miss
180				
43				
2				
191				
...				
181				
44				
186				
253				

5.2 (6%) How many total bits are required for a direct-mapped cache with 32 KiB of data, 8-word blocks, and 32-bit address?

6. (16% total) Assume that the CPI with a perfect cache is 2.0, the clock cycle time is 1.0 ns, there are 1.5 memory references per instruction, the size of both caches is 64 KB, and both have a block size of 64 bytes. One cache is direct mapped and the other is two-way set associative. Since the speed of the CPU is tied directly to the speed of a cache hit, assume the CPU clock cycle time must be stretched 1.3 times to accommodate the selection multiplexor of the set-associative cache. To the first approximation, the cache miss penalty is 80 ns for either cache organization. Assume the hit time is 1 clock cycle, the miss rate of a direct-mapped 64 KB cache is 1.5%, and the miss rate for a two-way set-associative cache of the same size is 1.1%.

6.1 (8%) Calculate the average memory access time for these two different cache organizations.

6.2 (8%) Calculate the CPU performance in terms of CPU time.

7. (20% total) Consider the virtual memory system.

7.1 (8%) The following list provides parameters of a virtual memory system.

Virtual Address (bits)	Physical DRAM Installed	Page Size	PTE Size (byte)
42	16 GiB	4 KiB	4

For a single-level page table, how many page table entries (PTEs) are needed? How much physical memory is needed for storing the page table?

7.2 (12%) The following data constitutes a stream of virtual address as seen on a system. Assume 4 KiB pages, a 4-entry fully associative TLB, and true LRU replacement. If pages must be brought in from disk, increment the next largest page number.

TLB

Valid	Tag	Physical Page Number
1	11	12
1	7	4
1	3	6
0	4	9

Page table

Valid	Physical Page or in Disk
1	5
0	Disk
0	Disk
1	6
1	9
1	11
0	Disk
1	4
0	Disk
0	Disk
1	3
1	12

Given the following address stream: 4669, 13916, …, and the initial TLB and page table states provided above, show the final state of the system. Also list for each reference if it is a hit in the TLB, a hit in the page table, or a page fault.

Address	Virtual Page	TLB H/M	TLB		
			Valid	Tag	Physical Page Number
4669					
13916					

國立中山大學 113 學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：作業系統【資工系資安碩班碩士班】

<div align="center">－作答注意事項－</div>

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。** 請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。

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- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。

- 試題採雙面列印，考生應注意試題頁數確實作答。

- 違規者依本校招生考試試場規則及違規處理辦法處理。

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. **[Operating System: 80%]**

   (1) Many criteria are used for measuring the performance of CPU-scheduling algorithms. (20%)
      a. Please explain the functionalities of the following criteria: 1). CPU utilization, 2). throughput, 3). turnaround time, 4). waiting time, and 5). response time. (10%)
      b. Please explain the following scheduling algorithms: 1). first-come, first-served (FCFS), 2). shortest-job-first (SJF), 3). priority, 4). round-robin, 5). multilevel queue, and 6). multilevel feedback queue. (10%)
   (2) Please explain the basic idea of redundant array of independent disks (RAID) and the levels of RAID from RAID 0 to RAID 6. Note that descriptions and figures are required to depict all these levels. (20%)
   (3) A client machine of a distributed system may need some approaches, be it client-initiated or server-initiated, to verify whether a locally cached copy of data is consistent with the copy on the master machine. Please explain the basic idea of client-initiated and server-initiated approaches and how they work. (10%)
   (4) Please show and explain the critical-section problem first and then explain the requirements of mutual exclusion, progress, and bounded waiting. (10%)
   (5) Various types of hardware failure can be found in a distributed system. Thus, to ensure that the distributed system is robust, we must detect these failures, reconfigure the system so that it can continue running, and recover when a site or a link is repaired. Please explain the following terms: failure detection, reconfiguration, recovery from failure, and fault tolerance. (20%)

2. **[Security: 20%]**
   (1) Explain what is Adversarial Example Attacks? (3%)
   (2) Explain what is Zero Trust Architecture (ZTA)? (3%)
   (3) Explain what is Privacy Enhancing Technology (PET)? (3%)
   (4) Explain what is Multi-Factor Authentication (MFA)? (3%)
   (5) Please describe what is a Grayware? (3%)
   (6) Please explain what the concept of end-to-end security for Instant Messenger apps is and how to achieve it. (5%)

國立中山大學 113 學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：離散數學與演算法【資工系資安碩班碩士班】

There are 9 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%] In how many ways can Richard assign 22 students in four classrooms so that there are at least three students in a classroom? (a student assigned different seats is considered as different cases in a classroom)

2. [10%] How many positive integers up to 188,071 that are relatively prime to 188,071?

3. (a) [10%] In how many ways can Peter select n candies from a large supply of four different kinds of candies (all of the same size) if the selection must include an even number of one specific type of candies?
   (b) [10%] In how many ways can Peter select n candies from a large supply of three different kinds of candies (all of the same size) if the selection must include odd numbers of two specific types of candies?

4. (10%) Find the generating function for the sequence $1, 2, 3, 4, 5, 5, 5, \ldots$.

5. A ship carries 60 food cans, 15 of each the chicken, beef, pork, and fish. Fifteen of these cans are placed to a lifeboat in order to supply foods for the rescue event.
   (a) [5%] How many possible choices that contains an even number of beef cans and an odd number of chicken cans?
   (b) [5%] How many possible choices that contains at least three pork cans or no pork cans at all?

6. [10%] An alphabet Σ consists of the five numeric characters 1, 2, 3, 4, 5, and the six alphabetic characters a, b, c, d, e, f. Find and solve a recurrence relation for the number of words of length n (in Σ^*), where there is no consecutive (identical or distinct) alphabetic characters.

7. (Algorithm points) [10%] Please express the algorithm of Quick Sort and analyze its time complexity in detail.

8. (Algorithm points) [10%] Please express the algorithm of Huffman coding and analyze its time complexity in detail.

9. (Algorithm points) [10%] Let T be a complete n-ary tree of height h with m leaves. Prove that $m \leq n^h$ and $h \geq \lceil \log_n m \rceil$.