# 國立中山大學114學年度
# 碩士班考試入學招生考試試題

**科目名稱：計算機結構【資工系碩士班甲組、乙組】**

—作答注意事項—

考試時間：100分鐘

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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)　　

1. (18%) A memory system is composed of **eight banks**, and each bank contains $2^{16}$ rows. Every DRAM row refresh is initiated by a command from the memory controller, and it refreshes a single row in a single DRAM bank. Each refresh command keeps the command bus busy for **5ns**. We define **command bus utilization** as the fraction of total execution time during which the command bus is occupied.

1.1 (6%) Given that the refresh interval is **64ms**, calculate the command bus utilization of refresh commands. Show your work step-by-step.
1.2 (12%) If **70%** of all rows can withstand a refresh interval of **256ms**, how does the command bus utilization of refresh command change? Calculate the reduction $(1 - \frac{new}{old})$ in bus utilization. Show your work step-by-step.

2. (14%) Assume we have a virtual memory detailed as follows:
- 256 MiB Physical Address Space
- 4 GiB Virtual Address Space
- 1 KiB page size
- A TLB with 4 sets that is 8-way associative with LRU replacement

2.1 (10%) How many bits will be used for **page offset**, **Virtual Page Number (VPN)**, **Physical Page Number (PPN)**, **TLB index**, and **TLB tag**?
2.2 (4%) How many entries are in this page table?

3. (18%) Assume a machine with a **7-stage** pipeline. Assume that branches are resolved in the sixth stage. Assume that 20% of instructions are branches.

3.1 (4%) How many instructions of wasted work are there per branch misprediction on this machine?
3.2 (4%) Assume **N** instructions are on the correct path of a program and assume a branch predictor accuracy of **A**. Write the equation for the number of instructions that are fetched on this machine in terms of **N** and **A**. (Show your work step by step)
3.3 (4%) Let's say we modify the machine so that it uses dual path execution (where an equal number of instructions are fetched from each of the two branch paths). Assume branches are resolved before new branches are fetched. Write how many instructions would be fetched in this case, as a function of **N**. (Show your work step by step)
3.4 (6%) Now let's say that the machine combines branch prediction and dual path execution in the following way: A branch confidence estimator is used to gauge how confident the machine is of the prediction made for a branch. When confidence in a prediction is high, the branch predictor's prediction is used to fetch the next instruction; when confidence in a prediction is low, dual path execution is used instead. Assume that the confidence estimator estimates a fraction **C** of the branch predictions have high confidence, and that the probability that the confidence estimator is wrong in its high confidence estimation is **M**. Write how many instructions would be fetched in this case, as a function of **N**, **A**, **C**, and **M**. (Show your work step by step)

4. (14%) Suppose that (after optimization) a typical **n**-instruction program requires an additional **4*n NOP** instructions to correctly handle data hazards.

4.1 (4%) Suppose that the cycle time of this pipeline without forwarding is 250 ps. Suppose also that adding forwarding hardware will reduce the number of **NOP**s from **0.4*n** to **0.05*n**, but increase the cycle time to 300 ps. What is the speedup of this new pipeline compared to the one without forwarding?
4.2 (4%) Can a program with only **0.075*n NOPs** possibly run faster on the pipeline with forwarding? Explain why or why not.
4.3. (6%) At minimum, how many **NOP**s (as a percentage of code instructions) must a program have before it can possibly run faster on the pipeline with forwarding?

5. (18%) Consider a single-issue in-order multithreading processor. Each cycle, the processor can fetch and issue one instruction that performs any of the following operations:

- **load/store, 13-cycle latency (fully pipelined)**
- **integer add, 1-cycle latency**
- **floating-point add, 6-cycle latency (fully pipelined)**
- **branch, no delay slots, 1-cycle latency**

The processor **does not have a cache**. Each memory operation directly accesses main memory. If an instruction cannot be issued due to a data dependency, the processor stalls. We also assume that the processor has a perfect branch predictor with no penalty for both taken and not-taken branches. Please analyze the processor utilizations for the following two thread-switching implementations:

**Fixed Switching:** the processor switches to a different thread every cycle using fixed round robin scheduling. Each of the N threads executes an instruction every N cycles.
**Data-dependent Switching:** the processor only switches to a different thread when an instruction cannot execute due to a data dependency.

Each thread executes the following RISC-V code:

```
loop:  LD    f2,   0 (x1)          # load data into f2
       ADDI  x1,   x1,   4         # bump pointer
       FADD  f3,   f3,   f2        # f3 = f3 + f2
       BNE   f2,   f4,   loop      # continue if f2 != f4
```

5.1 (8%) What is the minimum number of threads that we need to fully utilize the processor for each thread-switching implementation? Explain your reasoning.
5.2 (10%) What is the minimum number of threads that we need to fully utilize the processor for each thread-switching implementation if we change the **load/store latency to 1-cycle (but keep the 6-cycle floating-point add)**? Explain your reasoning.

6. (18%) Processor microarchitecture : VLIW vs. Superscalar vs. Array Processor

6.1 (3%) What do VLIW, superscalar execution, and array processing concepts have in common?
6.2 (6%) Provide two reasons why a VLIW microarchitecture is simpler than a "same-width" superscalar microarchitecture.
6.3 (3%) Provide a reason why a superscalar microarchitecture could provide higher performance than a "same-width" VLIW microarchitecture.
6.4 (3%) Provide a reason why a VLIW processor is more flexible than an array processor.
6.5 (3%) Provide a reason why an array processor is simpler than a "same-width" VLIW processor.

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

   (a) (6%)

```
int a=2, b=13, c;
for (c=1; b>0; b = b>>1) {
   if (b%2 == 1) c = c*a;
   a = a*a;
}
printf("%d \n", c);
```

   (b) (9%)

```
int a[64]={0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15};
int c=1;
for (int i=1; i<=3; i++) {
    for(int j=0; j<=15; j++)
        a[j] = a[j]+a[j+c];
    c *= 2;
}
printf("%d %d %d \n", a[0], a[5], a[14]);
```

2. The input elements for radix sort are 642, 374, 73, 29, 284, 252. Assume the radix base is 10.

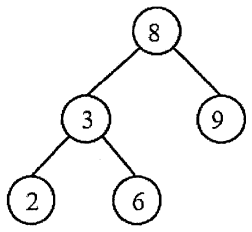
   (a) (5%) What is the sequence after the first pass finishes?

   (b) (5%) What is the sequence after the second pass finishes?

3. The following figure is an AVL tree.

   (a) (5%) Draw the AVL tree after a new element 1 is inserted.

   (b) (5%) Draw the AVL tree after a new element 4 is inserted (1 is not inserted).




4. A simple rule for the valid parenthesis format in a string consisting of left and right parentheses is that, for each pair of left parenthesis and right parenthesis, the left should appear first, followed by the right, possibly interrupted by zero or more pairs of left and right parentheses. For example, ( )( ), ( ( ) ), and ( ( ) ) ( ) are valid. But, ) (, ( ) ) (, and ) ) ( ) ( ( are invalid. Let $p(n)$, $n \geq 0$, denote the number of valid parenthesis strings for $n$ pairs of left and right parentheses. It is assumed that $p(0)=1$. Additionally, $p(1)=1$; $p(2)=2$, representing ( )( ) and ( ( ) ).

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

   (b) (10%) Please give the recurrence relation for calculating $p(n)$, for $n \geq 3$.

5. (a) (6%) In addition to the name, what are the other six common attributes of a file? Please briefly explain these attributes.
   (b) (4%) Please explain how the interrupt chaining method works.

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※本科目依簡章規定「不可以」使用計算機(問答申論題)　　

6. (a) (6%) There are three common types of hardware support to address the critical-section problem. Please briefly explain them.
   (b) (4%) Please explain two fundamental IPC (inter-process communication) models.

7. (10%) Please explain the five steps of TLB (translation look-aside buffer) operation.

8. (20%) Fill-in questions (2 points each)
   (a) When device A has a cable plugging into device B, and device B has a cable that plugs into device C, and device C plugs into a port on the computer, this arrangement is called a _____ chain.
   (b) Conceptually, the memory layout of a process includes text, data, _____, and stack sections.
   (c) A _____ condition may occur when several processes access the same data concurrently. Hence, the outcome of execution depends on a particular order in which the access takes place.
   (d) A deadlock situation can arise if four conditions hold at the same time: mutual exclusion, _____, no preemption, and circular wait.
   (e) The _____ code is non-self-modifying code; it never changes during execution.
   (f) Inverted page tables require that an _____ identifier be stored in each entry of page table.
   (g) Random-access time of an HDD device consists of seek time and _____.
   (h) The _____ time is the interval from the submission time of a process to its completion time (i.e., how long it takes to run the process).
   (i) Pthreads is a _____ standard for threads.
   (j) Swap space can be created in a _____ partition. No file system or directory structure is placed in this space.

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# 碩士班考試入學招生考試試題

**科目名稱：離散數學【資工系碩士班甲組】**

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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 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%] What is the value of *sum* after the following program segment is executed. (Here *i, j, k, increment,* and *sum* are integer variables.)

```
increment = 0
sum = 0
for i = 1 to 12 do
   for j = 1 to i do
      for k = 1 to j do
      begin
         increment = increment + 1
         sum = sum + increment
      end
```

2. [10%] Please prove the principle of mathematical induction by the well-ordering principle.

3. Let A= {1,2,3,4,5,6,7,8,9} and B={a,b,c,d,e,f,g,h}. Determine the number of functions $f$: A→B, where
   (a) [5%] f(A)={a,b,c}
   (b) [5%] |f(A)|=3

4. [10%] Find a sequence of ten distinct real numbers with no decreasing or increasing subsequence of length 3.

5. [10%] Construct a state diagram for a finite state machine with I = O = {0,1} that recognizes all strings in the language $\{0,0\}^*\{1,0\}\cup\{0,1\}^*\{00\}$.

6. (a) [10%] Find and solve a recurrence relation for the number of ways to perform two programs P1 and P2 sequently for $n$ seconds if each process of P1 requires one second and P2 needs four seconds.

   (b) [10%] Find and solve a recurrence relation for the number of ways to perform two programs P1 and P2 for $n$ seconds if each process of P1 requires one second and P2 needs four seconds, where the process of P2 for four different tasks and each P2 process with a different task is considered as a different process.

7. [10%] In how many ways, can Alice buy $n$ boxes of meat from a supermarket that sells pork, chicken, and beef (each kind of meat is of the same brand and size) if the selection must an even number of beef boxes (beef can buy one and get one free)?

8. [10%] If a 28-digital octal (0,1,2,3,4,5,6,7) sequence is randomly generated, what is the probability that it has an even number of 3's and even number of 7's?

9. [10%] Solve the following recurrence relation. $a_{n+2}^2 - 7a_{n+1}^2 + 12a_n^2 = 9n, n \geq 0, a_0 = a_1 = 1.$

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# 碩士班考試入學招生考試試題

**科目名稱：離散數學【資工系碩士班甲組】**

—作答注意事項—

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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- **違規者依本校招生考試試場規則及違規處理辦法處理。**

# 國立中山大學114學年度碩士班考試入學招生考試試題

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)　　

*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%] What is the value of *sum* after the following program segment is executed. (Here *i, j, k, increment,* and *sum* are integer variables.)

```
increment = 0
sum = 0
for i = 1 to 12 do
  for j = 1 to i do
    for k = 1 to j do
    begin
      increment = increment + 1
      sum = sum + increment
    end
```

2. [10%] Please prove the principle of mathematical induction by the well-ordering principle.

3. Let A= {1,2,3,4,5,6,7,8,9} and B={a,b,c,d,e,f,g,h}. Determine the number of functions $f$: A→B, where
   (a) [5%] f(A)={a,b,c}
   (b) [5%] |f(A)|=3

4. [10%] Find a sequence of ten distinct real numbers with no decreasing or increasing subsequence of length 3.

5. [10%] Construct a state diagram for a finite state machine with I = O = {0,1} that recognizes all strings in the language $\{0,0\}^*\{1,0\} \cup \{0,1\}^*\{00\}$.

6. (a) [10%] Find and solve a recurrence relation for the number of ways to perform two programs P1 and P2 sequently for $n$ seconds if each process of P1 requires one second and P2 needs four seconds.

   (b) [10%] Find and solve a recurrence relation for the number of ways to perform two programs P1 and P2 for $n$ seconds if each process of P1 requires one second and P2 needs four seconds, where the process of P2 for four different tasks and each P2 process with a different task is considered as a different process.

7. [10%] In how many ways, can Alice buy $n$ boxes of meat from a supermarket that sells pork, chicken, and beef (each kind of meat is of the same brand and size) if the selection must an even number of beef boxes (beef can buy one and get one free)?

8. [10%] If a 28-digital octal (0,1,2,3,4,5,6,7) sequence is randomly generated, what is the probability that it has an even number of 3's and even number of 7's?

9. [10%] Solve the following recurrence relation. $a_{n+2}^2 - 7a_{n+1}^2 + 12a_n^2 = 9n, n \geq 0, a_0 = a_1 = 1.$

# 國立中山大學114學年度
# 碩士班考試入學招生考試試題

**科目名稱：工程數學【資工系碩士班乙組】**

—作答注意事項—

考試時間：100分鐘

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# 國立中山大學114學年度碩士班考試入學招生考試試題

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 %) Using Gaussian elimination, find all solutions to the following system of linear equations.

$$2x_2 + 3x_3 + 4x_4 = 1$$
$$x_1 - 3x_2 + 4x_3 + 5x_4 = 2$$
$$-3x_1 + 10x_2 - 6x_3 - 7x_4 = -4$$

2. (16%) Compute the determinant in each of the following matrices. Indicate clearly the method being used.

2.1 (8%) $\begin{bmatrix} 2 & 0 & 0 & -3 & 1 \\ 0 & 0 & 0 & 0 & 7 \\ -3 & 2 & 0 & -1 & -6 \\ 2 & -2 & -1 & 1 & 4 \\ 0 & 0 & 0 & 4 & 3 \end{bmatrix}$

2.2 (8%) $\begin{bmatrix} 1 & b & b^2 \\ b & b^2 & b^3 \\ b^2 & b^3 & b^4 \end{bmatrix}$

3. (16%) The equation $x'' + 5x' + 6x = 0$

3.1 (10%) Solve the equation with $x(0) = 2, x'(0) = 3$
3.2 (6%) Find the maximum value attained by $x$.

4. (16%) Find a particular solution of $x'' - 3x' - 4x = 2sin\,t$

5. (16%) Solve $2x'' + x' + 2x = \delta(t-5)$ with $x(0) = x'(0) = 0$ by using Laplace transform.

6. (20%) A periodic function $f(x) = \begin{cases} -2x^2, & -(\pi/2) \le x < 0 \\ 2x^2, & 0 \le x < (\pi/2) \end{cases}$
$f(x+\pi) = f(x)$

6.1 (10%). Sketch the graph of the periodic function.
6.2 (10%). Find its full-range Fourier series on $[-(\pi/2), (\pi/2)]$

試題請隨卷繳回，請留意背面是否有題

# 國立中山大學114學年度
# 碩士班考試入學招生考試試題

**科目名稱：離散數學與演算法【資工系資安碩班碩士班】**

—作答注意事項—

考試時間：100 分鐘

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# 國立中山大學114學年度碩士班考試入學招生考試試題

科目名稱：離散數學與演算法【資工系資安碩班碩士班】　　題號：485001

※本科目依簡章規定「不可以」使用計算機(問答申論題)　　

*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%] There are how many different ways we can write the number of 13 as a sum of positive integers, where the order of the summands is considered relevant.

2. [10%] If $n \in Z^+$ and $n$ is composite, then there is a prime $p$ such that $p|n$. Please prove it using the well-ordering principle.

3. For distinct primes, $p, q$, let $A = \{p^m q^n | 0 \le m \le 29, 0 \le n \le 41\}$.
   (a) [5%] What is |A|?
   (b) [5%] If $f: A \times A \to A$ is the closed binary operation defined by $f(a, b) = \gcd(a, b)$, does $f$ have an identity element?

4. [10%] For $\Sigma = \{0,1\}$, let $A \subseteq \Sigma^*$, where $A = \{01, 1\}$. How many strings in $A^*$ have length 6?

5. [10%] Find the generating function for the number of integer solutions to the equation $c_1 + c_2 + c_3 + c_4 = 23$, where $-2 \le c_1, -4 \le c_2, -3 \le c_3 \le 6, 0 \le c_4$.

6. [10%] If a fair die is rolled for 15 times, what is the probability that the sum of the rolls is 43?

7. [10%] Solve the following recurrence relation. $a_{n+2} - 5a_{n+1} + 6a_n = 5^n, n \ge 0, a_0 = 0, a_1 = 1$.

8. (Algorithm Points) [10%] Please describe the algorithm of Heap Sort and analyze its time complexity in detail.

9. (Algorithm Points) [10%] Given a knapsack with maximum capacity $Q$ and a set $L$ consisting of $n$ items, where each item $i$ has weight $w_i$ and benefit value $a_i$. Please describe an algorithm in detail based on dynamic programming for packing the items in a knapsack to achieve a maximum total benefit value and analyze the time complexity of the algorithm. ($w_i$, $a_i$, $n$, and $Q$ are integer values.)

10. (Algorithm Points) [10%] Please describe the algorithm of minimum spanning tree and analyze its time complexity in detail.

# 國立中山大學114學年度
# 碩士班考試入學招生考試試題

**科目名稱：作業系統【資工系資安碩班碩士班】**

—作答注意事項—

考試時間：100分鐘

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# 國立中山大學114學年度碩士班考試入學招生考試試題

科目名稱：作業系統【資工系資安碩班碩士班】　　題號：485002

※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. [Operating System: 80%]**

(1) Please explain the redundant array of independent disks (RAID) and the RAID levels from 0 to 6, i.e., RAID 0, RAID 1, RAID 2, RAID 3, RAID 4, RAID 5, and RAID 6. Note that descriptions and figures are required to depict all these levels, such as name, basic idea, and how it works. (20%)

(2) Please explain the basic ideas of the following program threats: Trojan horse, trap door, logic bomb, and stack and buffer overflow. (20%)

(3) Please show and explain the difference between nonvirtual machine and virtual machine using figures and descriptions. (10%)

(4) Please show and explain the basic idea of cloud computing and edge computing. (10%)

(5) The cancellation of a target thread may occur in the following two different scenarios: asynchronous cancellation and deferred cancellation. Please explain the main features of these two scenarios, the difficulties they may encounter, and possible OS solutions. (20%)

**2. [Security: 20%]**

(1) Explain what is Prompt Attack? (3%)

(2) Explain what is Fake News? (3%)

(3) Explain what is Secure Computation? (3%)

(4) Explain what is Personal Identifiable Information (PII)? (3%)

(5) Please describe what is Post Quantum Cryptography? (3%)

(6) Please explain what the concept of Data Science for Malware Detection is and how to achieve it. (5%)