教育部 113 年公費留學考試試題 103

科目：計算機結構 （全三頁，第一頁）

※可使用工程計算機(限僅具備＋、－、×、÷、% 、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

※可用中文或英文作答，評分基準相同。

1. (25 points) Please identify the false statements/descriptions with explanations in the questions below.
   (a) (5 points) A general-purpose processor often uses a small, fast memory known as cache memory. This cache can mitigate the memory wall issue because it is built using dynamic random access memory (DRAM) technology and functions as a buffer for the data stored in DRAM, reducing data access latency for the processor.
   (b) (5 points) Addition operations follow associative property, and this property holds for both integer and floating-point numbers.
   (c) (5 points) In a two-level cache system, the primary goal of the first-level cache is to reduce the miss rate, while the second-level cache focuses on improving hit time.
   (d) (5 points) Pipelining techniques can be applied across different process technologies. For instance, employing a delayed branch is a straightforward method to mitigate the overhead caused by control hazards, making it especially advantageous for processors with extended pipelines or with an advanced process technology.
   (e) (5 points) Various metrics are useful for measuring and comparing the performance of different processors. These include execution time, CPU time, millions of instructions per second (MIPS), and CPU clock cycles.

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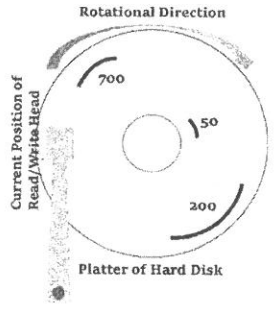
2. (25 points) Please answer the questions below.
   (a) (5 points) What is the loop unrolling technique and how this technique can help the program execution on a processor?
   (b) (5 points) What is the definition of memory buffer?
   (c) (5 points) What is the definition of cache memory?
   (d) (5 points) What is the Instruction Level Parallelism (ILP) technology?
   (e) (5 points) Asynchronous I/O operations can improve the system throughput. Which of the following techniques can be used to implement asynchronous I/O? 1. Memory Buffer. 2. Cache Memory. 3. Instruction Pipelining. 4. Superscalar Execution. Please explain your answer.

3. (20 points) Consider a computer with a main processor that includes a 64-entry TLB. The computer features a hard disk (HD) operating at 5400 RPM, containing 40 sectors, and a sector size of 512 bytes. The HD also has a seek time of 30 ms and an access latency time of 10 ms.
   (a) (5 points) Calculate TLB reach when the computer supports memory page sizes of 1 KB and 4 KB, respectively.
   (b) (5 points) Compute the data transfer rate of the hard disk in KB/s.
   (c) (5 points) Estimate the I/O times when page faults occur; give your I/O times in milliseconds for handling the page fault of a 1-KB page and a 4-KB page, respectively.
   (d) (5 points) We assume that the data transfer time of the HD is proportional to the page size. What are the I/O times to transfer the same amount of data (i.e., 4KB data) with 1-KB and 4-KB pages, respectively? In such a case, if we want to minimize the I/O time on the computer, which page size (1 KB or 4KB) is desired?

（接下頁）

4. (30 points) I/O accesses significantly impact overall system performance. Rescheduling I/O accesses to hard disks is a common practice to enhance performance. Consider an application that generates three I/O Read operations on three different logical block addresses in the sequence: (700, 50, 200), and the physical locations of the logical block addresses are illustrated below.



Please determine the best schedules that will deliver the minimal disk access times in different conditions.

(a) (10 points) The OS can reschedule the I/O accesses to improve the performance. For example, OS reschedules the accesses in the sequence (50, 200, 700). Does the OS always deliver the best schedule given the logical block addresses? Why?

(b) (10 points)What is the best sequence for the I/O accesses when the disk seek time is far larger than its rotational delay? Why?

(c) (10 points)What is the best sequence for the I/O accesses when the disk rotational delay is far larger than its seek time? Why?

教育部 113 年公費留學考試試題 104

科目：演算法 （全一頁）

※可使用工程計算機(限僅具備＋、－、×、÷、% 、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

※以中文或英文作答均可，評分基準相同。

1. Solve the following recurrences. You only need to obtain the asymptotic solution (in $\Theta()$ notation). Prove your answer formally. If you use the master theorem, you must specify all parameters and briefly verify all the conditions.

   (a) (10%) $T(1) = 1, T(n) = 5T(\lfloor \frac{n}{5} \rfloor) + n \log_2 n, \forall n \geq 2.$

   (b) (10%) $T(0) = T(1) = 1, T(n) = T(\lfloor \frac{n}{3} \rfloor) + T(\lfloor \frac{n}{4} \rfloor) + T(\lfloor \frac{n}{5} \rfloor) + n, \forall n \geq 2.$

2. Given n types of distinct coins. The i-th type worth a_i dollars. $a_1 < a_2 < \cdots < a_n$. $a_1 = 1$ and a_i is a positive integer for all $i > 1$. Assume that you have an infinite number of each type, given a positive integer C, the goal is to find the smallest number of coins that sum up to C dollars.

   (a) (5%) A greedy algorithm finds the coins using the following procedure: starting with the highest-valued coin n, use as many coins of each type as possible before considering the next lower denomination. Show that this algorithm does not necessarily generate a solution with the minimum number of coins.

   (b) (10%) Prove that, if $\frac{a_i}{a_{i-1}}$ is a positive integer for $i = 2, 3, \ldots, n$, then the above greedy algorithm always gives an optimal solution.

3. Your goal is to split n children $a_1, a_2, \ldots, a_n$ into k equal sized groups $g_1, g_2, \ldots, g_k$ such that every child in group g_i is taller than every child in group g_j for every $i > j$. You are only allowed to directly compare the height of two children. (You may assume that n and k are both powers of 2 and every child has a different height.)

   (a) (15%) Design an algorithm with running time $O(n \log k)$. You will receive partial credit for an $O(nk)$ algorithm. Briefly justify the running time and the correctness of your algorithm.

   (b) (10%) Prove that the time complexity of this problem is $\Omega(n \log k)$.

4. For each of the following two problems, you must either design a polynomial time algorithm or prove that the problem is NP-complete.

   (a) (20%) Given an n by n integer matrix, determine whether it is possible to permute (exchange) rows such that all diagonal elements $a_{11}, a_{22}, \ldots, a_{nn}$ are odd numbers.

   (b) (20%) Given an undirected graph G. Each edge has a (possibly negative) edge cost. Determine whether the graph G has a simple cycle of total cost 0.

（試題隨試卷繳回）

教育部 113 年公費留學考試試題　105

科目：計算機程式　（全二頁，第一頁）

※可使用工程計算機(限僅具備＋、－、×、÷、%　、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

※以中文或英文作答均可，評分基準相同。

※Your code should be in C/C++, Python, or a well-defined pseudocode style. Include proper comments whenever possible.

1. (15%) Consider n different types of data with index from 0 to $n-1$. Given m tuples of the form (x_i, y_i), $i = 1$ to m, where $x_i \in \{0, \ldots, n-1\}$ indicates the type of data and y_i is an integer score of x_i, write a procedure to find the number of the data types that have total score greater than an integral threshold T.

2. (15%) Let A be an array with n positive integers, which are smaller than n^4. Design a procedure that can sort A in $O(n)$ time. Explain your idea.

3. (15%) Design an efficient procedure to merge k sorted arrays: A[1],…,A[k], into a single sorted array B. Explain your idea.

4. (15%) Given two strings X and Y, each of length n and with lower case English alphabet, design an efficient procedure to determine if it is possible to swap at most two characters from one of the strings such that they represent the same string. Your procedure should return True or False. For example, let X='abcd' and Y='adcb'. Then, we can swap 'd' and 'b' in Y, such that Y='abcd', which is identical to X. Or, we can swap 'b' and 'd' in X. In this case, it should return True.

（接下頁）

5. (20%) Consider the system of inequalities of n variables, where each inequality is of the form $x_j - x_i \leq b_k$. For example, the following system of inequalities consists of three inequalities for variables x_1, x_2, x_3:

$$\begin{cases} x_1 - x_2 \leq 1 \\ x_2 - x_3 \leq 2 \\ x_1 - x_3 \leq -2 \end{cases}$$

Suppose there are m inequalities. Without using Linear Programming, design an efficient procedure to determine if the system has a feasible solution or not. Explain your idea. What is the complexity of your method?

6. (20%) Given an integer array A of size n, find the length of the longest increasing subsequence. Design an efficient procedure with dynamic programming to solve this problem. Explain your idea. What is the time complexity of your method?

教育部 113 年公費留學考試試題 106

科目：線性代數 （全二頁，第一頁）

※可使用**工程**計算機(限僅具備＋、－、×、÷、% 、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

※以中文或英文作答均可，評分基準相同。

1. (25%) Let

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 3 & 4 \\ 3 & 4 & 5 \end{bmatrix}$$

(a) Compute the determinant of A. Is A nonsingular? (10%)

(b) Compute adj A and the product A adj A. (15%)

2. (20%) Let $[x, 1]$ and $[2x - 1, 2x + 1]$ be ordered bases for P_2.

(a) Find the transition matrix representing the change in coordinates from $[2x - 1, 2x + 1]$ to $[x, 1]$. (10%)

(b) Find the transition matrix representing the change in coordinates from $[x, 1]$ to $[2x - 1, 2x + 1]$. (10%)

3.(20%) Let E = $\{\mathbf{u}_1, \mathbf{u}_2, \mathbf{u}_3\}$ and F = $\{\mathbf{b}_1, \mathbf{b}_2\}$, where

$$\mathbf{u}_1 = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}, \quad \mathbf{u}_2 = \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}, \quad \mathbf{u}_3 = \begin{bmatrix} -1 \\ 1 \\ 1 \end{bmatrix}$$

and

$$\mathbf{b}_1 = (1, -1)^T, \quad \mathbf{b}_2 = (2, -1)^T$$

For each of the following linear transformations L from R^3 into R^2, find the matrix representing L with respect to the ordered bases E and F:

(a) $L(x) = (x_3, x_1)^T$ (10%)

(b) $L(x) = (2x_2, -x_1)^T$ (10%)

4. Let A be a 2×2 matrix. If $\text{tr}(A) = 8$ and $\det(A) = 12$, what are the eigenvalues of A? (15%)

（接下頁）

教育部 113 年公費留學考試試題　106

科目：線性代數　　（全二頁，第二頁）

5. For each of the following matrix A, determine a basis for each of the subspaces $R(A^T)$, $N(A)$, $R(A)$, and $N(A^T)$, where $R(A)$ is range of A and $N(A)$ is null space of A.　(20%)

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

（試題隨試卷繳回）

教育部 113 年公費留學考試試題 109

科目：資訊安全概論 （全一頁）

※可使用工程計算機(限僅具備＋、－、×、÷、% 、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

一、(總分 25 分)拒絕服務(Denial-of-Service)攻擊已成為當前駭客針對網路服務的常見攻擊手法，而具體的攻擊方式可能因情況而異。請回答以下相關問題：

(一) 請舉例一項基於 TCP 網路協定的拒絕服務攻擊，並且說明如何透過耗盡系統資源(System Resources)進行攻擊。(8 分)

(二) 請說明針對 HTTP 協定的 Slowloris 攻擊，並解釋這是一種如何耗盡應用程式資源(Application Resources)的拒絕服務攻擊。(8 分)

(三) 請說明 DNS 反射(Reflection)攻擊。(9 分)

二、(總分 25 分)請使用兩個函數 P 和 Q 劃出堆疊框架(Stack Frame)的架構圖，並藉此說明以下有關堆疊溢位(Stack Overflow)攻擊的相關問題。架構圖應至少需包含以下元素：返回位址(Return Address)、框架指標(Frame Pointer)、被呼叫函數的參數(Parameters)和局部變數(Local Variables)。

(一) 請說明如何利用 Stack Overflow 取得 Shell。(12 分)

(二) 請說明如何基於 Canary Value 防禦 Stack Overflow 攻擊。(13 分)

三、(總分 25 分)針對地址解析協議(Address Resolution Protocol，ARP)欺騙(Spoofing)和網頁釣魚(Web Page Phishing)攻擊，請以 Wi-Fi 網路為例回答以下問題。

(一) 請說明如何基於 ARP 欺騙進行中間人攻擊。(8 分)

(二) 基於中間人攻擊，請說明如何利用 DNS 欺騙進行網頁釣魚攻擊。(8 分)

(三) 請說明如何防禦 ARP 欺騙攻擊。(9 分)

四、資料庫加密是保護資料庫的最後一道防線，但由於其高昂的成本，尚未被廣泛應用。請說明該防護工具的兩項主要缺點，以及對應的可能解決方法。(25 分)

(試題隨試卷繳回)

教育部 113 年公費留學考試試題　110

科目：離散數學　　（全一頁）

※可使用工程計算機(限僅具備+、－、×、÷、%、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

※以中文或英文作答均可，評分基準相同。

1. What is the probability that none of the n couples pair with their spouse as n goes to infinity? (20%)

2. You have two copies of letter A and an unlimited supply of letters B, C and D. How many words of length 9 can you make from this such that all A's are used, the fifth letter is an A, and there is no B appearing between A's. (20%)

3. Eight problems are distributed to four students, each getting at least one problem. Two problems are easy and therefore cannot be distributed to the same student. How many ways are the distributions of the eight problems to the four students? (15%)

4. Let G=(V,E) and H=(V,F) be simple undirected graphs, where V is the vertex set, and E and F are the edge sets. The union of E and F forms the edge set of the complete graph on V. Prove or disprove the following statement: One of G or H must be connected. (15%)

5. $(a_i)_{i=0}^{\infty}$ is the sequence generated by $\sum_{i=0}^{\infty} a_i x^i$. List out the first five terms of the sequence generated by $[(1-x-x^2)(1-x)]^{-1}$. (15%)

6. How many words can be made by rearranging aaabbccdd, such that no `a' appears somewhere to the right of some `c'. (15%)

（試題隨試卷繳回）

教育部 113 年公費留學考試試題　111

科目：半導體物理　　（全二頁，第一頁）

※可使用工程計算機(限僅具備＋、－、×、÷、%、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

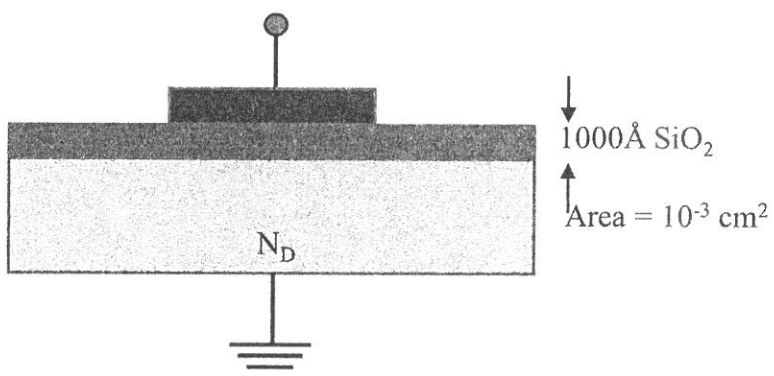
※以中文或英文作答均可，評分基準相同。

1. (15%) Define the following terms. Use a few words as possible to correctly define each.
   (a) Fermi Level: (3%)
   (b) Drift velocity: (3%)
   (c) Extrinsic Semiconductor: (3%)
   (d) Indirect Recombination: (3%)
   (e) Schottky Contact: (3%)

2. (15%) Si atoms are added to a piece of GaAs. The Si can replace either trivalent Ga or pentavalent As atoms. Assume that Si atoms act as fully ionized dopant atoms and 5% of the $10^{10}cm^{-3}$ Si atoms replace Ga atoms and 95% replace As atoms. The sample temperature is 300K. Assume that for GaAs at 300K, $n_i = 9\times10^6\ cm^{-3}$, $\mu_n = 8800\ cm^2V^{-1}S^{-1}$, $\mu_p = 400\ cm^2V^{-1}S^{-1}$, $E_g = 1.42eV$, $N_C = 1.04\times10^{19}cm^{-3}$, $N_V = 6\times10^{18}cm^{-3}$, $q = 1.6\times10^{-19}C$.
   (a) Calculate the donor and acceptor concentrations? (5%)
   (b) Find the electron and hole concentration and the location of the Fermi level compare to intrinsic Fermi level. (5%)
   (c) Find the conductivity of the GaAs assuming that lattice scattering is dominant. (5%)

3. (15%) Assume a p-n junction made from silicon with $N_D = n_n = 10^{16}cm^{-3}$, $N_A = P_p = 10^{17}cm^{-3}$, $n_i = 1.5\times10^{10}cm^{-3}$, $T = 300K$, $q = 1.6\times10^{-19}C$. Calculate n_p (2%) and p_n (2%) far away from the junction, V_{bi} (2%), W (2%), and the peak electric field (2%). Assume a step junction of area 0.1 cm^2. What is the capacitance of the junction (5%)?

4. (15%) An MOS capacitor is fabricated on N-type silicon as shown below.



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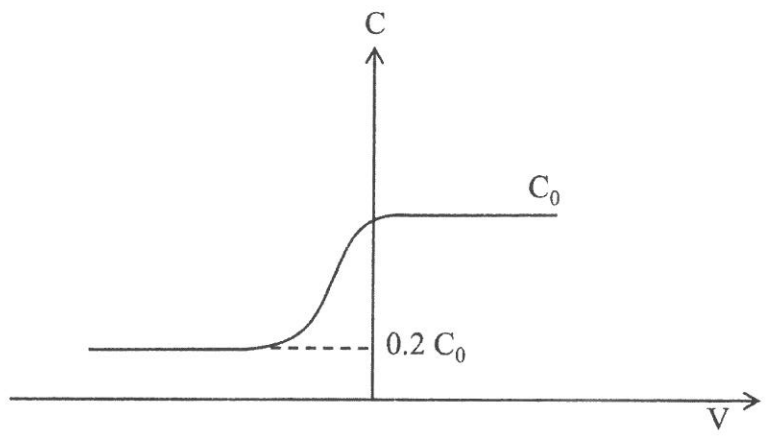
(a) Plot the CV curves of an ideal MOS capacitor, and explain the mechanism of different region (accumulation, depletion and inversion). (5%)
(b) A C-V measurement is made on the samples as shown below. Calculate the depletion width in the Silicon. (5%)
(c) Explain physically why the CV measurement result shows a constant C_{min}. (5%)



5. (20%) A p-channel MOS transistor is fabricated on a N substrate with $N_D = 10^{15}$ cm^{-3} and a gate oxide thickness of 1000Å. $\epsilon_{SiO2} = 3.9$, $\epsilon_0 = 8.85\times10^{-14}$ F/cm, T =300K, $q = 1.6\times10^{-19}$C.
(a) Calculate the threshold voltage if Φ_{MS} = -0.2 eV and $N_{ss} = 5\times10^{11}$/cm^2. (10%)
(b) The threshold voltage of the MOSFET in (a) is reduced by using boron ion implantation into the channel under the gate. If the energy of the implanted boron is chosen to replace the entire dose within the surface depletion region. What is the require dose (ions/cm^2) in order to obtain a threshold voltage of -1.5V? (10%)

6. (20%) GaN related materials can be used to build high electron mobility transistor. For AlGaN/GaN HEMT device, assume that for $Al_xGa_{1-x}N$, $E_{g1} = 4.2$ eV, $\chi_1 = 3.54$ eV, $E_{C1} - E_{F1} = 0.3$ eV, for GaN, $E_{g2} = 3.42$ eV, $\chi_2 = 4.1$ eV, $E_{F2} - E_{V2} = 0.5$ eV.
(a) Plot the energy band diagram of the AlGaN/GaN device. (10%)
(b) Can this transistor be used for high power applications? (10%)

教育部 113 年公費留學考試試題 112

科目：電子學 （全三頁，第一頁）

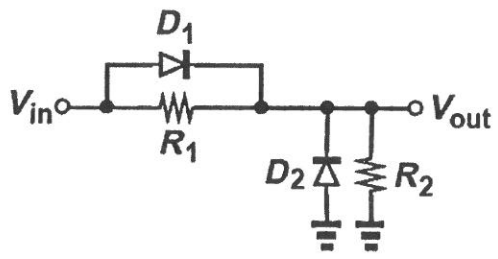
※可使用工程計算機(限僅具備＋、－、×、÷、% 、√、MR、MC、M+、M-、三角函數、對數、指數運算功能)

※以中文或英文作答均可，評分基準相同。

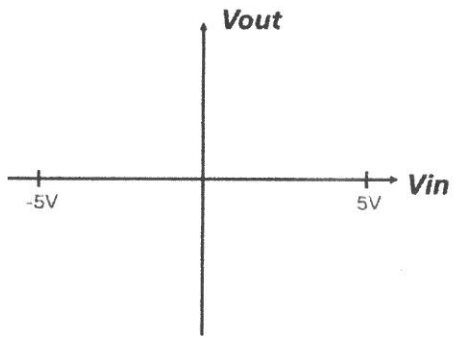
Please use the following parameters for all the NMOS and PMOS devices in all problems if needed.

$$\mu_n C_{ox} = 0.2\,\text{mA/V}^2\,,\ \mu_p C_{ox} = 0.1\,\text{mA/V}^2\,,$$
$$V_{THn} = 0.5\text{V},\ |V_{THp}| = 0.5\text{V},$$

1. (25%) **Circuit A** is a circuit with diodes and resistors. Let $R_1 = 5\text{k}\Omega$, $R_2 = 10\text{k}\Omega$, and apply constant-voltage model with $V_{D,on} = 0.8\text{V}$ for each diode.



Circuit A



1.1 Please plot the input-to-output characteristic curve for input voltage from -5V to 5V. (10%)

1.2 Calculate the slope change points and mark them on the transfer curve in 1.1. (6%)

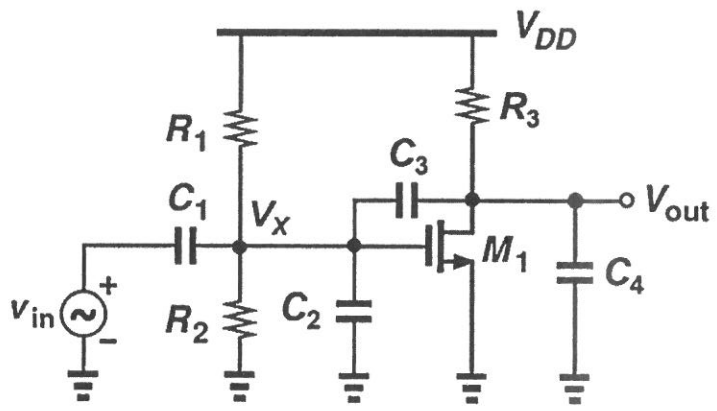
1.3 Calculate the slope of each segment and mark them on the transfer curve in 1.1. (9%)

（接下頁）

教育部 113 年公費留學考試試題 112

科目：電子學 （全三頁，第二頁）

2. (40%) **Circuit B** shows the common-source amplifier with the biasing circuit, where the transconductance of M_1 transistor g_{m1}=2mA/V. The supply voltage V_{DD} is 3V. R_1=200KΩ, R_2=100KΩ, R_3=2KΩ, C_1=500pF, C_2=0.3pF, C_3=0.1pF, and C_4=10pF. If there is no channel length modulation effect for M_1, please apply **Miller theorem** for the following questions.



Circuit B

2.1. What are the input and output operation voltages of M_1 transistor? (10%)

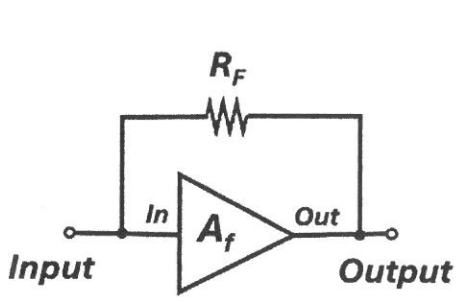
2.2. Please use parameters of g_{m1}, $R_{1\sim3}$, $C_{1\sim4}$ to express the frequency response of $V_X/v_{in}\,(s)$. (5%)

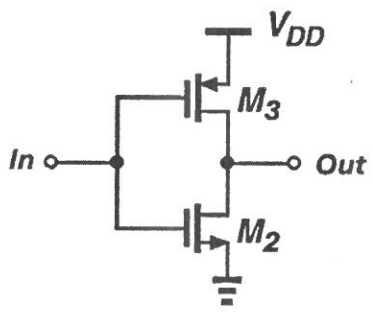
2.3. Like 2.2, please express the frequency response of $V_{out}/V_X\,(s)$. (5%)

2.4. Please draw the Bode plot of $|V_{out}/v_{in}\,(\omega)|$, and mark the mid-band gain and the position of poles/zeros with exact values in V/V and rad/sec respectively. (20%)

（接下頁）

3. (35%) Below is a feedback-type transimpedance amplifier, with its core amplifier A_f as the **Circuit C**. The feedback resistor R_F=1KΩ. Supply voltage V_{DD} is 2V. In the core amplifier, M_2 size $(W/L)_2$= $(50\mu m/1\mu m)$, M_3 size $(W/L)_3$= $(100\mu m/1\mu m)$, and $\lambda_2 = \lambda_3 = 0.1\,V^{-1}$.





Circuit C

3.1. What kind of feedback configuration (shunt/series, shunt/series) of this amplifier? (5%)

3.2. What is the transimpedance gain if the core amplifier is ideal? (5%)

3.3. Please draw the small signal model of this transimpedance amplifier. (5%)

3.4. If there is no current flow thru R_F in the closed-loop operation, based on 3.3 and the real device values, please calculate the closed-loop transimpedance gain, closed-loop input and output impedance respectively. (20%)