國立中山大學 105 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)　　

1. [Process and Synchronization: 10%]

(1) What is the priority inversion problem? How can we solve this problem? (4%)

(2) Please explain how a deadlock avoidance scheme works? (3%)

(3) Please give three necessary conditions for any solution to the critical-section problem. (3%)

2. [File System and I/O: 10%]

(1) What is a mount point? (2%)

(2) What is the advantage of multilevel naming? (2%)

(3) What are the two parts of the random-access time for a magnetic disk? (2%)

(4) Please explain the two interrupt request lines for a CPU? (4%)

3. [Memory Management: 15%]

(1) Please explain the three common solutions to the dynamic storage allocation problem in memory. (6%)

(2) What are the purposes of MMU and TLB? (2%)

(3) Show that a stack algorithm will never encounter the Belady's anomaly. (4%)

(4) How does the Buddy system work to allocate kernel memory? (3%)

4. [Protection and Security: 15%]

(1) Please give three methods to implement a protection domain and explain when domain switching will occur in each method. (3%)

(2) Please list the advantages of using language-based protection. (4%)

(3) What is the difference between a computer virus and a computer worm? (4%)

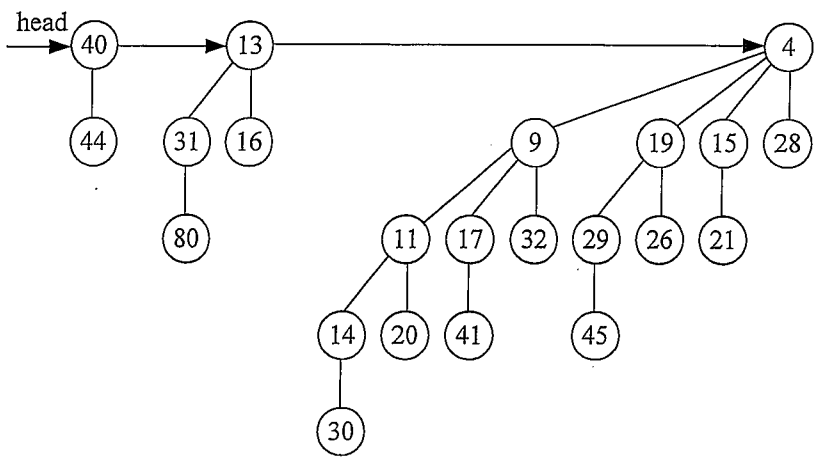
(4) In asymmetric encryption, how do you realize key distribution? (2%)

(5) What is the difference between signature-based and anomaly detection? (2%)

5. [Hash and Heap: 10%]

(1) Supposing that we store n keys in a hash table with size of n^2 by a universal hash function, prove that the collision probability is less than 0.5. (5%)

(2) Given a binomial heap below, please show the result of extracting the node with minimum key. (5%)



6. [Search and Sort: 10%]

(1) What is the major property of a binary search tree? (2%)

(2) Given a set of numbers 8, 2, 7, 9, 14, 16, 3, 1, 4, and 10, draw the heap used by the heapsort method. (5%)

(3) Prove that the best-case complexity of the quicksort method is $O(n \lg n)$. (3%)

試題隨卷繳回　背面有題

7. [Trees: 15%]

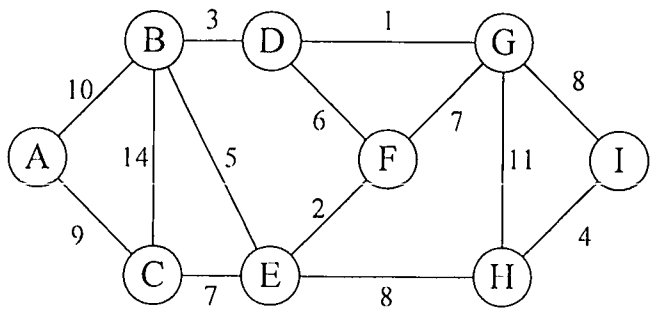
(1) What are the two major properties of a tree? (2%)

(2) Prove that any red-black tree with k internal nodes can have a height no more than $2\lg(k+1)$. (10%)

(3) Explain three variants of a B-tree: B^+-tree, B^*-tree, and 2-3-4 tree. (3%)

8. [Graphs: 15%]

Given a graph below, please answer the following questions, where you should denote an edge between two vertices i and j by (i, j).



(1) Starting from node E, give the sequence by bread-first-search. If you have multiple choices, just follow the alphabetical order. (3%)

(2) Starting from node D, give the sequence by depth-first-search. If you have multiple choices, just follow the alphabetical order. (3%)

(3) Show the result by the Kruskal's algorithm. (3%)

(4) Starting from node I, show the result by the Prim's algorithm. (3%)

(5) Show the minimum connected dominating set. (3%)

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國立中山大學105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)　　

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

1. (15) Show that for any positive integer n, there exists a *positive integer* m such that n divides m (namely, $m = kn$ for some integer k), and the decimal digits of m are only 0 and 1. For example, $n = 7$, $m = 1001$. In addition to show that this is true in general, use $n = 7$ and $n = 12$ to show how to find such m.

2. (15) Let N be the set of all positive integers, and $S = \mathrm{N} \times \mathrm{N}$, (namely, $S = \{(x, y) \mid x, y \in \mathrm{N}\}$). Show that there is a bijection (one-one and onto) function $f : S \to \mathrm{N}$, or show that no such function exists.

3. (15) Let $m > 1$ and $n > 1$ be two positive integers. Let $r(m, n)$ denotes the *maximum* number of rectangles defined by m horizontal lines and n vertical lines in a plane. Derive a formula for $r(m, n)$, and justify your answer. Note that rectangles may overlap. For example, let $m = 2$ and $n = 3$ ( ), $r(2, 3) = 3$, not 2.

4. (15) A *line segment* in R^2 is a line joining 2 different points in R^2. Two lines intersect if they share a common point. Show that in any 6 line segments in R^2, *either* there are 3 line segments in which any pair of them intersect *or* there are 3 line segments in which no pair of them intersect.

5. (10) Let the sequence of numbers $g_0, g_1, \ldots, g_n, \ldots$ be defined by $g_0 = 0$, $g_1 = 1$, and, for every $n > 1$, $g_n = g_{n-1} + g_{n-2}$. Solve g_n, in terms of n, by the method of generating functions.

6. (15) The girth of a graph G is the length of the shortest cycle in G. Let G be a simple graph with ν vertices, ϵ edges, and girth g. It is known that if G is planar, then $\epsilon \leq \frac{g}{g-2}(\nu - 2)$. Let K_5 be a complete graph with 5 vertices, and $K_{3,3}$ be a complete bipartite graph with 3 vertices in each partition. Draw K_5 and $K_{3,3}$, and show that they are not planar.

7. (15) Let L be the set of binary strings whose values are multiple of 7, (namely, $L = \{0, 111, 1110, 10101, \ldots\}$). Design a finite state machine $M = (Q, \Sigma, \delta, q_0, F)$ to recognize the language L. Although no formal proof is required, you should explain why your machine M accepts only strings in L, and every binary string in L is accepted by M.

試題隨卷繳回

國立中山大學105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. (24%) Suppose that we have a system (showing in Figure 1) consisting of two interconnected tanks, each containing a brine solution. Tank A contains $x(t)$ pounds of salt in 200 gallons of brine, and tank B contains $y(t)$ pounds of salt in 300 gallons of brine. The mixture in each tank is kept uniform by constant stirring. When $t = 0$, brine is pumped from tank A to tanks B at 20 gallons/minute and from tank B to tank A at 20 gallons/minute. If $x(0) = 10$ and $y(0) = 40$.

1.1 (4%) Please find the system of the differential equation in matrix form.

1.2 (4%) Please find the characteristic polynomial of the coefficient matrix from 1.1.

1.3 (4%) Please find the eigenvalues and associated eigenvectors from 1.1 and 1.2.

1.4 (4%) Please find the general solution in matrix form.

1.5 (8%) Please find the amount of salt in each tank at time t.

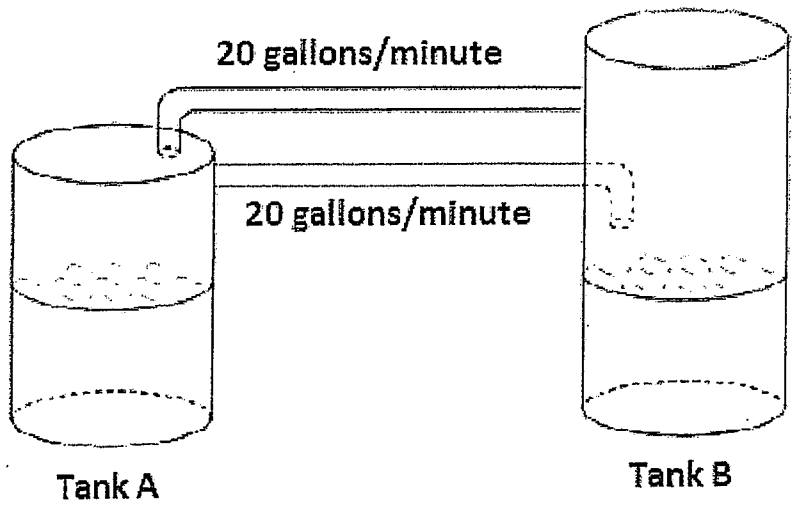

Figure 1

2. (16%) The system shown in Figure 2 can be represented by the following two equations.

$$Li_1' + R(i_1 - i_2) = v(t)$$

$$R(i_2' - i_1') + \frac{1}{C} i_2 = 0$$

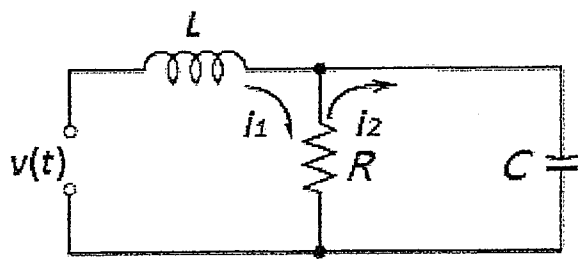

Figure 2

Solve this system by the Laplace transform and the Inverse Laplace transform, where $R = 1\ \Omega$, $L = 2$ H, $C = 0.5$F, $v(t) = 90\ e^{-t/4}$ V, $i_1(0) = 0$, $i_2(0) = 2$ A.

試題隨卷繳回　背面有題

3. (12%) Considering the periodic function $x(t)$ plotted in the following Figure 3,

3.1 (6%) Find the DC value a_0 and other Fourier coefficients a_k for $k \neq 0$ in the Fourier series representation of $x(t)$.

3.2 (6%) Define a new signal as $y(t) = 2x(t - T_0/2)$. Use the linearity and time shifting property to write down the Fourier series coefficient b_k for $k \neq 0$ for the periodic signal $y(t)$ without evaluating any integrals.

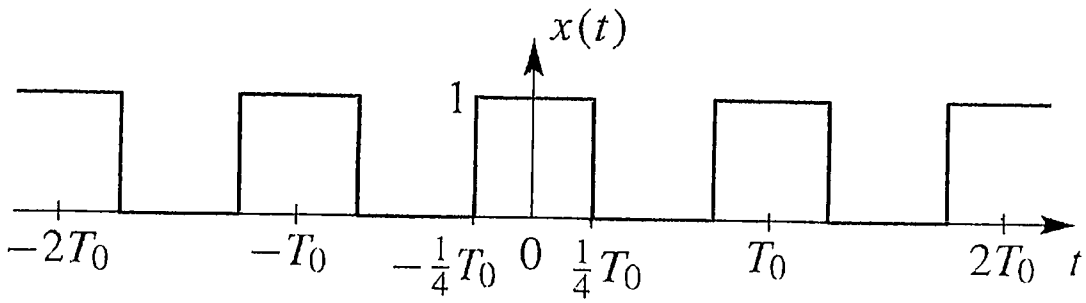

Figure 3

4. (20%) Let $A = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$

4.1 (4%) Determine a simple expression for A^2 and show the detail of your calculations.

4.2 (6%) Determine a simple expression for A^3 and show the detail of your calculations.

4.3 (4%) Conjecture the form of a simple expression for A^k, k is a positive integer.

4.4 (6%) Prove or disprove your conjecture in 4.3.

5. (12%) In a bimolecular reaction $A + B \rightarrow M$, a moles per liter of a substance A and b moles per liter of a substance B are combined. Under constant temperature the rate of reaction is

$$y' = k(a - y)(b - y)$$

, that is, y' is proportional to the product of the concentration of the substances that are reacting, where $y(t)$ is the number of moles per liter which have reacted after time t. Solve this ODE, assuming that $a \neq b$.

6. (16%) Find the general solution of the following equation and show the detail of your calculations.

$$(4x^2D^2 - 24xD + 49I)y = 36x^5$$

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國立中山大學105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)　　

1. (20 %) SIMD, SIMT, VLIW, Superscalar, Superpipeline
   1.1 (4%) Explain the major features of single instruction multiple data (SIMD) processor. In other words, point out the major differences between SIMD CPU and conventional CPU. Give a practical example of SIMD instructions, CPU, or computer.
   1.2 (4%) Compare the differences of thread and process. Is context switching the change of threads or the change of process?
   1.3 (4%) Explain the major features of single instruction multiple threads (SIMT) processor. Give a practical example of SIMT computer.
   1.4 (4%) Explain the major features of very long instruction word (VLIW) processor. Which processor category does VLIW belong to, static multiple issue or dynamic multiple issue?
   1.5 (4%) What is a superscalar processor? What is a superpipeline processor?

2. (20%) Cache
   2.1 (4%) Give two methods to reduce cache miss rate.
   2.2 (4%) Give two methods to reduce cache hit time.
   2.3 (4%) Give two methods to reduce cache miss penalty.
   2.4 (4%) For the following Figure 1, explain the reason why the miss rate goes down as the block size increases to a certain level, and explain the reason why the miss rate goes up if the block size is too large relative to the cache size.

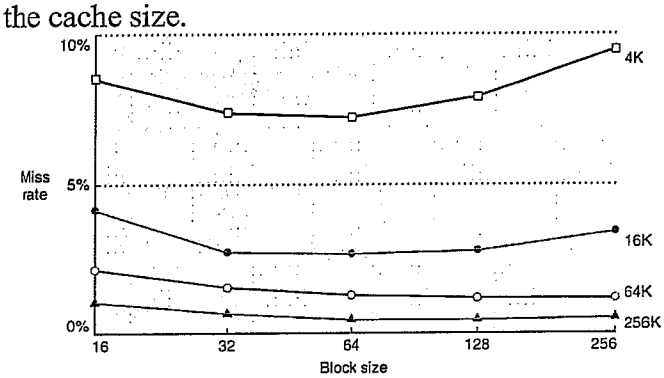

Figure 1.

   2.5 (4%) Explain the differences of write-allocate and no-write-allocate during cache write miss.

3. (20%) The execution of an instruction can be divided into five parts: instruction fetch (IF), register read (RR), ALU operation (EX), data access (MEM), and register write (RW). The following Table 1 shows the execution time of each part for several types of instructions, assuming that the multiplexors, and control unit have no delay.

Table 1.

Instruction class	Instruction fetch	Register read	ALU operation	Data access	Register write
Load word (lw)	200 ps	100 ps	200 ps	200 ps	100 ps
Store word (sw)	200 ps	100 ps	200 ps	200 ps	
R-format (add, sub, AND, OR, slt)	200 ps	100 ps	200 ps		100 ps
Branch (beq)	200 ps	100 ps	200 ps		

If instructions are to be executed in a pipelined CPU with five pipeline stages, IF, RR, EX, MEM, RW where the pipeline stages execute the corresponding operations mentioned above.
   3.1 (4%) What is the cycle time of the pipelined CPU? What is the maximum working frequency?
   3.2 (4%) What is the latency of executing the load-word instruction (lw) in the pipelined CPU?
   3.3 (4%) What is the latency of executing the add instruction (add) in the pipelined CPU?
   3.4 (4%) What is the maximum throughput of the pipelined CPU?
   3.5 (4%) Propose a design method to increase the throughput performance of the pipelined CPU.

4. (20%) Memory Hierarchy

The following Figure 2 shows the process of going from a virtual address to a data item in cache. Answer the following questions based on this figure.

4.1 (4%) What is the purpose of the translation lookaside buffer (TLB)?

4.2 (4%) Is the TLB direct mapped, set associative, or full associative? Is the data cache, direct mapped, set associative, or fully associative?

4.3 (4%) What is the page size? What is the block size of the data cache?

4.4 (4%) What is the size of the data cache (excluding the tags)? What is the maximum size of physical memory supported in this memory system?

4.5 (4%) Is the cache virtually addressed or a physically addressed?

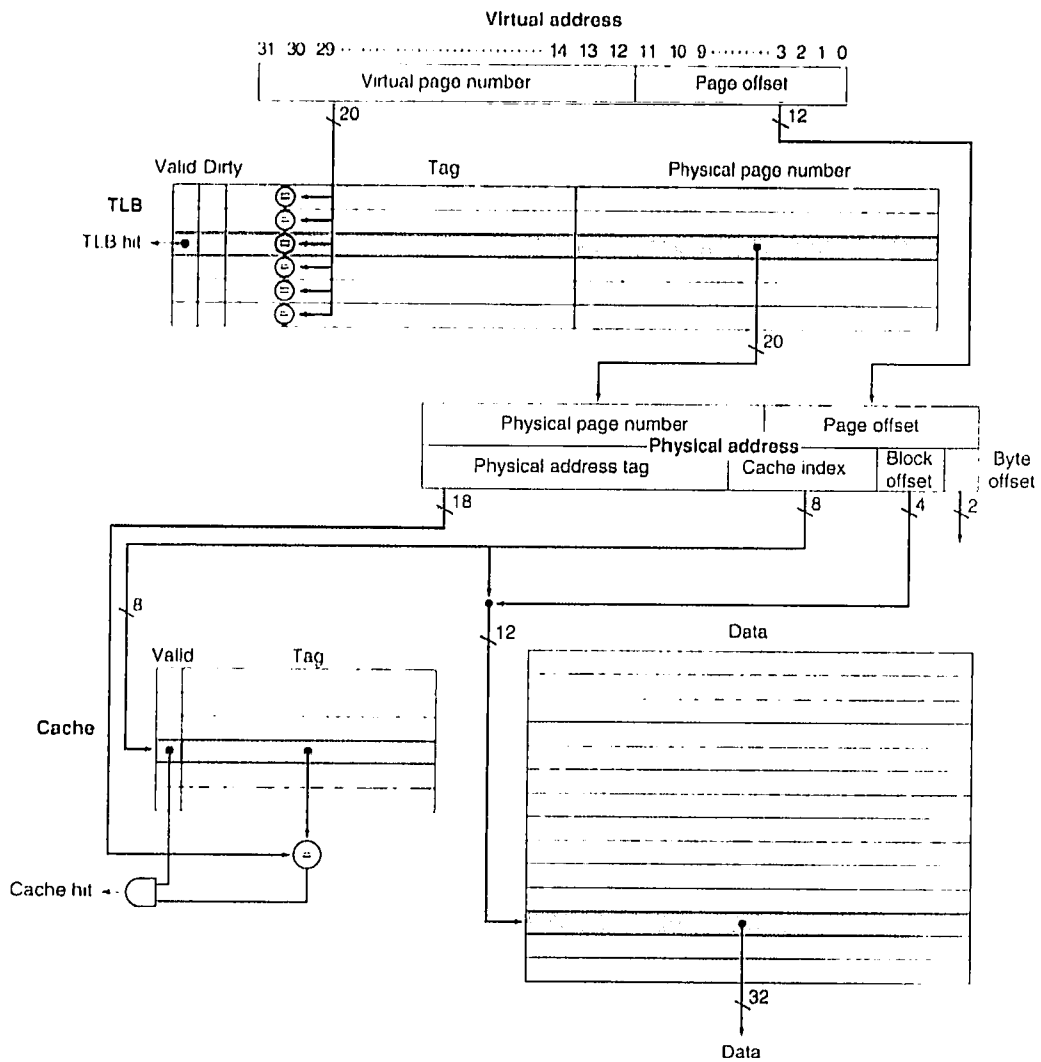

Figure 2.

5. (20%) Answer the following questions.

5.1 (4%) What are the differences of arithmetic mean and geometric mean? Is geometric mean or arithmetic mean used by SPECINT2006 to summarize the speed measurements for several benchmark programs?

5.2 The following Figure 3 shows the growth in processor performance since mid-1980s. Answer the following questions.

5.2.1 (4%) Is the vertical axis of Figure 3 linear scale or log-scale? What is the growth rate, linear or exponential, if it is a straight line in a particular time interval in Figure 3?

5.2.2 (4%) Give two possible reasons for the large performance growth rate from 1986 to 2002.

5.2.3 (4%) Give two possible reasons to explain why the growth rate slows down after 2002.

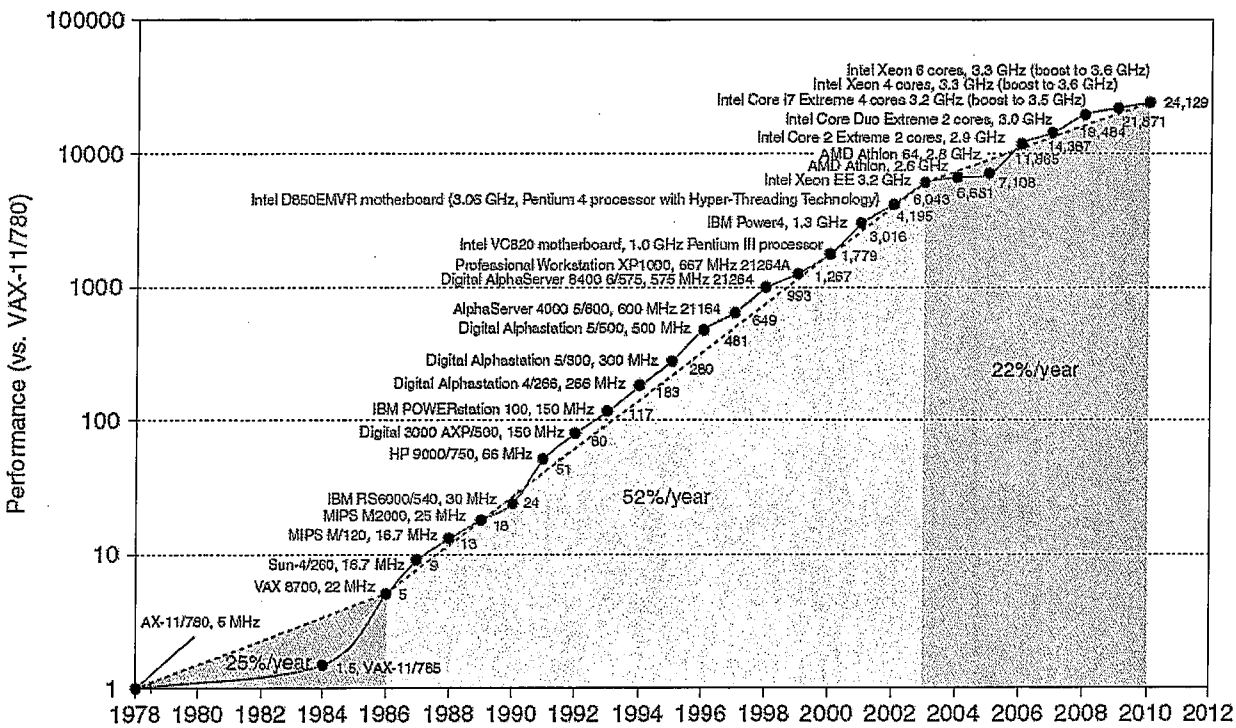

Figure 3.

5.3 (4%) Give two design methods to increase the performance of executing conditional branch instructions.