INDIAN STATISTICAL INSTITUTE

Mid-Semester-Examination: 2013-2014 M.Tech. (CS) First Year

Computer Organization

Date: 26.08.2013 **Maximum marks = 60** Final Credit: 30%

Time: 3 hours

Name:________________________ **Roll No.:**________________________

Instructions (Read carefully)

A. This is an **OPEN BOOK/OPEN NOTES** exam. Answer all questions; partial credit may be given for incomplete/incorrect answers.

B. Total points = 70; **maximum score = 60.**

C. You may write your answer on the test booklet itself.

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1. **(2 points)** Add the following two sign-magnitude numbers and express the result in 16-bit 2's complement binary:

   1001000100
   0001000010

2. **(3 points)** Represent the following 2's complement number into IEEE 754 single precision format:

   1111 1111 1111 0001

3a. **(5 points)** Consider the number N = 1 10000001 1000 0000 0000 0000 0000 000 in the following IEEE 754 floating point format:

S (1-bit)	E (8-bit)	M (23-bit)

Write the number N in fractional binary and in decimal notation.

3b. **(15 points)** Let a positive normalized floating point number N be given, and let *$t1* and *$t2* be two 32-bit registers as in MIPS, which hold the strings E and M respectively, each logically extended on the left (i.e., required MSB's filled with 0's). Now, given the contents of *$t1* and *$t2* as inputs, suggest an algorithm for checking whether or not N can be expressed as a 32-bit 2's complement integer. For instance, in the case of the floating point number given in Problem 3a, the answer is yes. Next, envisage a scheme in MIPS to implement this. You may use integer arithmetic instructions (signed, unsigned, immediate), logical (AND, OR, XOR, including immediate mode), branch, and shift (logical left/right, arithmetic left/right) instructions, as needed. Assume availability of general pupose registers such as *$t0, $t1,....., $s0, $s1,....., $zero,* as necessary.

(8 +7)

4. **(5 points)** You are given a 16-bit full adder which is capable of *adding* two integers $A = a_{15}\, a_{14} \ldots a_0$ and $B = b_{15}\, b_{14} \ldots b_0$ in 2's complement, producing the sum $S = s_{15}\, s_{14} \ldots s_0$. Let c_i denote the carry emanating out from the i-th stage, $i = 0, 1, \ldots.15$. Consider a function $F(A, B) = c_{15} \oplus c_{14}$. Give an example of A and B such that $F(A,B) = 1$. Just your argument.

5. **(10 points)** You are given an 16-bit integer A in 2's complement form stored in an 16-bit register $R1$. We need a dedicated ALU to compute $\lfloor 131A/4 \rfloor$ for various input values of A and save the result in a 32-bit register $R2$. Show a schematic design the ALU using a block diagram; assume that only multiple units of 32-bit full-adders, MUXes, shift-registers and other basic control logic blocks are available, and no multiplier or divider block is available. Justify the rationale behind your design.

(5 +5)

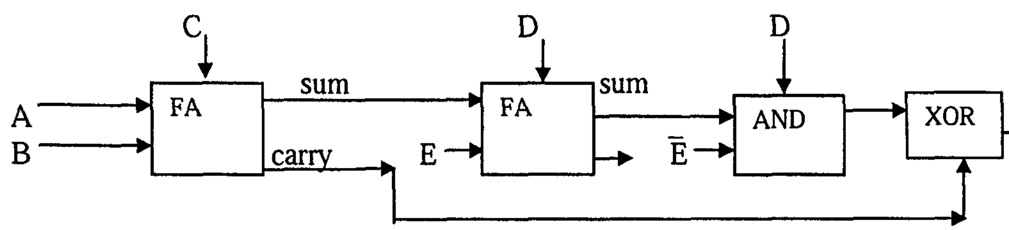
6. **(10 points)** A program P contains 20% tasks which are to be sequentially executed on a machine M1. A new 80-core machine M2 has now been designed, which consists of 80 copies of M1 on a chip. Calculate the maximum achievable speed-up S_A in respect to execution time of the new machine M2 relative to machine M1, for the program P following Amdahl's argument. Next, compute the scaled speed-up S_G for the machine M2 relative to M1 following Gustavson's argument. Derive the expressions for speed-up in both the cases and justify your derivation. In your analysis, you may neglect the inter-processor transaction time.

(5 + 5)

7. **(10 points)** Consider the following MIPS code running on a machine M1, whose clock cycle time (CCT) is 10 *ns*. Assume that each of the instructions can be completed within a clock cycle. Calculate the total amount of CPU-time required to execute the code.

```
       lw $t1, 1000($t2) (load ($t1) from a word in memory)
       lw $t2, 1000($t2)
       add $ t2, $t2, $t2 (add signed; destination, source1, source2)
Loop:  add $ t1, $t1, $t1
       beq $t1, $t2, Loop (branch to Loop if ($t1) = ($t2))
       sw $t2, 1000($t3) (store ($t1) as a word in memory)
```

8. **(10 points)** In the following circuit, two full-adder (FA) blocks, one AND and one XOR gate are connected as shown. If the logic values of the inputs (A, B, C, D, E) are randomly chosen, what is the probability that F = 1?
(Hint: Please don't waste time in constructing the truth-table; use logical justification based on the properties of parity and majority functions)



INDIAN STATISTICAL INSTITUTE

Mid-Sem Examination

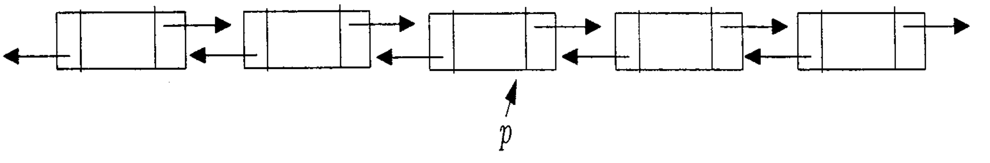
M. Tech. - I Year (Semester - I)

Data and File Structures

Date : 28 Aug. 2013 | Maximum Marks : 60 | Duration : 2:30 Hours

Note : The question is of 75 marks. You may answer any part of any question, but maximum you can score is 60.

1. There is a doubly linked list storing 0's and 1's, and what you are provided with is just a reference p to a node in this list storing 0. You need to find out the nearest node containing 1. Your algorithm must run in time $O(x)$, where x is the distance to nearest node in the linked list. Note that you know neither x nor the direction (from p) of the nearest node storing 1. You can use only one variable for reference and initially it is assigned p. You may use a constant number of integer variables though.



[15]

2. Prove that no matter what node we start at in a height-h binary search tree, k-successive calls to Tree-successor (that is inorder successor) will take $O(k+h)$ time. [15]

3. You are given a number x and an array $A[1,..n]$ storing n positive numbers such that $A[1]+...+A[i] \leq A[i+1]$ for each $i \geq 1$. Design a polynomial time algorithm to determine if there exist $1 \leq i_1 < i_2 < \ldots < i_t \leq n$ such that $A[i_1]+A[i_2]+\ldots+A[i_t]=x$. [15]

4. Design an efficient data structure to perform the following operations on an array $A[0,n-1]$ in worst case $O(logn)$ time.

   Report Sum(j) : return $\Sigma_{i \leq j} A[i]$

   Increment(i,x) : add x to $A[i]$. [15]

5. Show that any n-node tree can be transformed into any other arbitrary n-node tree using $O(n)$ rotations. Here the rotation operation is same as the rotation operation we use in AVL tree for height rebalancing. [15]

INDIAN STATISTICAL INSTITUTE
Mid-Semestral Examination: 2013-14

Course Name: Mtech (CS) I Year

Subject Name: Introduction to Programming

Date: 30/08/2013 | Maximum Marks: 30 | Duration: 3hrs

Answer all Questions. Clearly mention your assumptions if any.

1. Answer the following questions: **(10x1=10)**
   a. What will be the output of the following code? Explain your answer.
   ```
   #define SQUARE (X) X * X
   int main()
   {
       printf ("\nSQUARE (%d) = %d",10+2,SQUARE(10+2));
   }
   ```
   b. Which of the following operator has the lowest priority?
   (i) ++ (ii) % (iii) + (iv) ||

   c. Does a static variable get initialised to some value by default? If yes, to what value?

   d. Which of the following is not a relational operator?
   (i) ! (ii) != (ii) >= (iv) <

   e. Which among the following is a unconditional control structure?
   (i) `do ... while` (ii) `if ... else` (iii) `goto ...` (iv) `for ...`

   f. Is there any operator in the following?
   (i) , (ii) % (iii) # (iv) { }

   g. Pointer is of what data type?

   h. Differentiate between the expression "++a" and "a++"? Explain you answer.

2. Write a C function to find out longest palindrome in a given string (as parameter). **4**

3. Given two integer arrays `a` and `b` with `n` and `m` numbers stored in them respectively. Write a C function to find the numbers that are not present in the second array. **4**

4. Write a C program to find out if two rectangles R1 and R2 are overlapping? **4**

5. You have to climb `n` steps of a ladder. You can climb either climb 1 step at a time or 2 steps a time. Write a C function to return number of ways to climb a ladder with n step. **8**

INDIAN STATISTICAL INSTITUTE

PERIODICAL EXAMINATION
M.TECH.(CS) I YEAR

ELEMENTS OF ALGEBRAIC STRUCTURES

Date: 02.09.2012 Maximum marks: 70 Duration: 2 hours

The paper contains 82 marks. Answer as much as you can, the maximum you can score is 70.

1. (a) Show that if sets A and B are countably infinite, then so is $A \cup B$.
   (b) Solve the equations for x and y: $15x \equiv 1 \bmod 17$ and $15y \equiv 1 \bmod 31$.
   (c) Use the Chinese remainder theorem to solve the equation for z: $15z \equiv 2 \bmod 17 \times 31$.

$(6 + 6 + 8 = 20)$

2. (a) Show that Z_{23}^* has a cyclic subgroup H of order 11 and find all the generators of H.
   (b) Let
   $$\pi = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ 4 & 7 & 8 & 2 & 5 & 3 & 1 & 6 \end{pmatrix} \text{ and } \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ 4 & 1 & 8 & 2 & 6 & 3 & 7 & 5 \end{pmatrix}$$
   Are these two conjugate permutations? If so, exhibit a conjugating permutation.
   (c) Is the additive group of rationals cyclic? Justify your answer.

$(8 + 6 + 6 = 20)$

3. (a) Show that if the centre of a group G is of index n in G, then every conjugacy class of G has at most n elements.
   (b) Let G be a group and N be a normal subgroup of G of index n. Show that $g^n \in N$ for all $g \in G$.
   (c) Let G be a group such that the intersection of all its subgroups which are different from $\{e\}$ is a subgroup which is different from $\{e\}$. Show that every element of G has finite order.
   (d) A subgroup C of G is said to be a characteristic subgroup of G if $T(C) \subset C$ for all automorphisms T of G. Prove that a characteristic subgroup must be normal.
   (e) Let G be a group and Z be its centre. Show that if G/Z is cyclic, then G is abelian.
   (f) If N is normal in G and $a \in G$, then show that the order m of Na in G/N is a divisor of $o(a)$.

$(7 + 7 + 7 + 7 + 7 + 7 = 42)$

INDIAN STATISTICAL INSTITUTE

Mid-Semestral Examination

M.Tech(CS)-I Year, 2013-2014 (Semester-I)

Discrete Mathematics

Date: **September 4, 2013** Maximum Marks: **80** Duration: **3 Hours**

Note: The question paper carries a total of 90 marks. You can answer as much as you can, but the maximu you can score is 80.

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1. (a) Prove that $\forall n \in \mathbb{N}, 2^{4n} - 1$ is divisible by 15 ($\mathbb{N}$ is the set of positive integers).
   (b) Let a, b, n be positive integers. Prove that $2^{n-1}(a^n + b^n) \geq (a+b)^n$.
   (c) Derive an expression for the maximum number of regions that can be formed within a circle by drawi n chords.

(4+7+7=1

2. (a) Let S be a subset of $\{10, 11, \ldots, 98, 99\}$ containing 10 elements. Prove that there will always exist t disjoint subsets A and B of S, such that sum of the elements of A is equal to the sum of the elements B.
   (b) Let n be any positive integer and $\phi(n)$ be the Euler function. Then prove that

$$\phi(n) = n \prod_{i=1}^{k} (1 - \tfrac{1}{p_i})$$

   where $n = p_1^{\alpha_1} p_2^{\alpha_2} \cdots p_k^{\alpha_k}$ and $p_1, p_2, \cdots, p_k$ are distinct primes.
   (c) Given a positive integer n, for which values of k is $\binom{n}{k}$ maximum? Justify your answer.

(10+6+7=

3. (a) Call a ternary string (string over $\{0, 1, 2\}$) *lovely* if every 0 is immediately followed by a 1 and every 1 immediately followed by a 2. For instance, the strings 0120120120, 01212, and 222201 are all *lovely*, b 0120112 is not *lovely*. Let a_n denote the number of ternary strings of length n that are *lovely*.
      (i) Derive a recurrence relation that defines the sequence $a_0, a_1, a_2, \cdots$.
      (ii) Prove that $a_n \geq (\sqrt[3]{3})^n$ holds for all $n \in \mathbb{N}$
   (b) Let

$$T(n) = \begin{cases} T(\frac{n}{2}) + 1 & \text{if } n \text{ is even;} \\ 2T(\frac{n-1}{2}) & \text{if } n \text{ is odd;} \end{cases}$$

   Show that
      (i) for infinitely many values of n, $T(n) = \Theta(\log n)$
      (ii) for infinitely many values of n, $T(n) = \Omega(n)$

((6+6)+(4+8)=

4. (a) Prove or disprove the following statements:
      (i) $f(n) \in \Theta(g(n)) \Rightarrow 2^{f(n)} \in \Theta(2^{g(n)})$
      (ii) $f(n) \notin o(g(n))$ and $f(n) \notin \omega(g(n)) \Rightarrow f(n) \in \Theta(g(n))$
   (b) Let $R(z) = \frac{P(z)}{Q(z)}$ be a rational function, where $Q(z)$ has distinct nonzero real roots. Derive an expres for the coefficient of z^n in $R(z)$.

((5+5)+15=

INDIAN STATISTICAL INSTITUTE

Mid Semestral Examination

M. Tech (CS) - I Year, 2013-2014 (Semester - I)

Probability and Stochastic Processes

Date : 06.09.2013 Maximum Marks : 60 Duration : 3 Hours

Note: The question is of 75 marks.

Answer as much as you can, but the maximum you can score is 60.

(Q1) Let there be n sticks each of which is broken into one long and one short part. The $2n$ parts are arranged into n pairs from which new sticks are formed. Find the probability that

(a) the parts will be joined in the original order.

(b) that all long parts are paired with short parts.

[5+3=8]

(Q2) A parallel system having n components functions when at least one of the components functions. A component i, independent of other components, functions with probability p_i, $i = 1, \dots, n$. What is the probability that the system functions? [5]

(Q3) State and prove Bayes' formula. [7]

(Q4) Consider a collection of $N + 1$ boxes, each containing a total of N red and white balls. The box number i contains i red and $N - i$ white balls ($i = 0, 1, \dots, N$). A box is chosen at random and n random draws are made from it, the ball drawn being replaced each time. Find the conditional probability that the $n + 1$-th drawing from the box will also yield a red ball given that all the prior n balls turn out to be red. [8]

(Q5) Independent trials, each resulting in a success with probability p or a failure with probability $q = 1 - p$, are performed. Compute the probability that a run of n consecutive successes occurs before a run of m consecutive failures. [10]

(Q6) Consider the following gambling game. A player holds a bet on any one of the numbers $\{1, 2, 3, 4, 5, 6\}$. Three dice are then rolled, and if the number bet by the player appears i times, $i = 1, 2, 3$, then the player wins i units. On the other hand, if the number bet by the player does not appear on any of the dice, then the player loses 1 unit. Find out if the game is fair to the player? [5]

(Q7) Let X be a random variable defined over a sample space Ω such that $\mathrm{E}[X] = \mu$. Show that $\Pr(X \geq \mu) > 0$ and $\Pr(X \leq \mu) > 0$. [3+3=6]

[Hints: Can you try to prove using contradiction?]

(Q8) Suppose we roll a standard fair die 200 times. Let X be the sum of the numbers that appear over the 200 rolls. Use Chebyshev's inequality to bound $\mathbf{Pr}[X \geq 750]$. [6]

(Q9) Let X be a uniform random variable on $[u, v]$. Show that $\Pr(X \leq m | X \leq n) = \frac{m-u}{n-u}$, where $u \leq m \leq n \leq v$. [6]

(Q10) Let $X_1, \ldots, X_n$ be independent uniform random variables over $[0, 1]$. Let $Y_1 = \min(X_1, \ldots, X_n)$. Show that $\mathrm{E}[Y_1] = \frac{1}{n+1}$. [8]

(Q11) For an exponential random variable show that $\Pr(X > s + t \mid X > t) = \Pr(X > s)$. [6]

INDIAN STATISTICAL INSTITUTE

Semestral Examination

M.Tech.(CS)-I Year, 2013-2014 (Semester-I)

Discrete Mathematics

Date: **November 11, 2013** Maximum Marks: **100** Duration: **3.5 Hours**

Note: The question paper carries a total of 126 marks. You can answer as much as you can, but the maximum you can score is 100. **The notations have their usual meanings.**

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1. (a) Find the number of solutions to the following equation:

$$x_1 + x_2 + x_3 = 17$$

where x_1, x_2, x_3 are nonnegative integers, and $2 \leq x_1 \leq 5$, $3 \leq x_2 \leq 6$, and $4 \leq x_3 \leq 7$.

(b) Find the number of positive integers less than or equal to 1000 that are divisible by 7, 10 or 15.

(c) Prove that, given any 12 natural numbers, we can choose two of them and such that their difference is divisible by 11.

(d) Prove that $\forall n \in \mathbb{N}$,

$$1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n} = \frac{k}{m}$$

where k is an odd number and m is an even number.

(6+7+7+8=28)

2. (a) Let $f(n)$ and $g(n)$ be positive functions. Prove or disprove the following statement: $f(n) \in O(g(n))$ implies that $g(n) \in O(f(n) + g(n))$.

(b) Solve the following recurrence relations:

(i) $f(0) = 1, f(1) = 2, f(2) = 0$ and $f(n) = 7f(n-1) - 16f(n-2) + 12f(n-3)$ if $n \geq 3$.

(ii) $T(n) = \begin{cases} 2 & \text{if } n = 1; \\ 3T(\lfloor \frac{n}{2} \rfloor) + n\log_2(n) & \text{if } n > 1. \end{cases}$

(c) A computer system considers a string of decimal digits a valid codeword if it contains an even number of 0's. For instance, 1230407869 is valid, whereas 120987045608 is not valid. Let a_n be the number of valid n-digit codewords. Derive a recurrence relation for a_n.

(5+(5+6)+6=22)

3. (a) Consider K_6, the complete graph with 6 vertices. Color every edge of K_6 with one of the two colors, namely red or blue. Prove that it has a monocromatic triangle (i.e., a triangle with all edges of same color).

(b) A *matching* in a graph is defined as a set of edges with no two edges in the set having any common vertex. A *perfect matching* is a matching, such that every vertex in the graph has an incident edge in the matching. Let $G = (V, E)$ be an undirected graph such that $|V| = 2p$, and the degree of each vertex is at least p. Prove that G has a perfect matching.

(7+10=17)

4. (a) Prove that every planar graph is *5-colorable.*

   (b) A graph G is called *randomly Hamiltonian* if a hamiltonian cycle always results when we start from an arbitrary vertex and then successively proceed to any adjacent vertex not yet chosen until no new vertices are available. For example K_5 is randomly hamiltonian. Give *three* examples of randomly hamiltonian graphs with 6 vertices each.

(12+7=19))

5. (a) Let G be a nontrivial connected graph with p vertices. Prove that $\alpha_0 + \beta_0 = p = \alpha_1 + \beta_1$, where α_0, α_1, β_0 and β_1 are the vertex cover number, edge cover number, vertex independence number, and edge independence number respectively.

   (b) Let G be a bipartite graph with q edges. Prove that $q \leq \alpha_0 . \beta_0$.

(9+6=15)

6. (a) Prove that for any graph G with p vertices, $p/\beta_0 \leq \chi \leq p - \beta_0 + 1$, where χ and β_0 are the chromatic number and vertex independence number of G respectively.

   (b) The *eccentricity* $e(v)$ of a vertex v in a connected graph G is defined as $max\ d(u, v)$ for all vertices u in G. The *radius* $r(G)$ is the minimum eccentricity of the vertices. The maximum eccentricity is called the *diameter*. A vertex v is a *central point* if $e(v) = r(G)$ and the *center* of G is the set of all central points. Prove that every *tree* has a center consisting of either one vertex or two adjacent vertices.

(6+9=15)

7. (a) Prove that the propositions $\neg(p \wedge q)$ and $\neg p \vee \neg q$ are logically equivalent.

   (b) Without using truth table, prove that $\neg(p \vee q) \vee (\neg p \wedge q) \equiv \neg p$.

(4+6=10)

INDIAN STATISTICAL INSTITUTE

First-Semestral-Examination: 2013-2014 M.Tech. (CS) First Year

Computer Organization

Date: November 13, 2013 **Maximum marks = 100** Credit: 50%

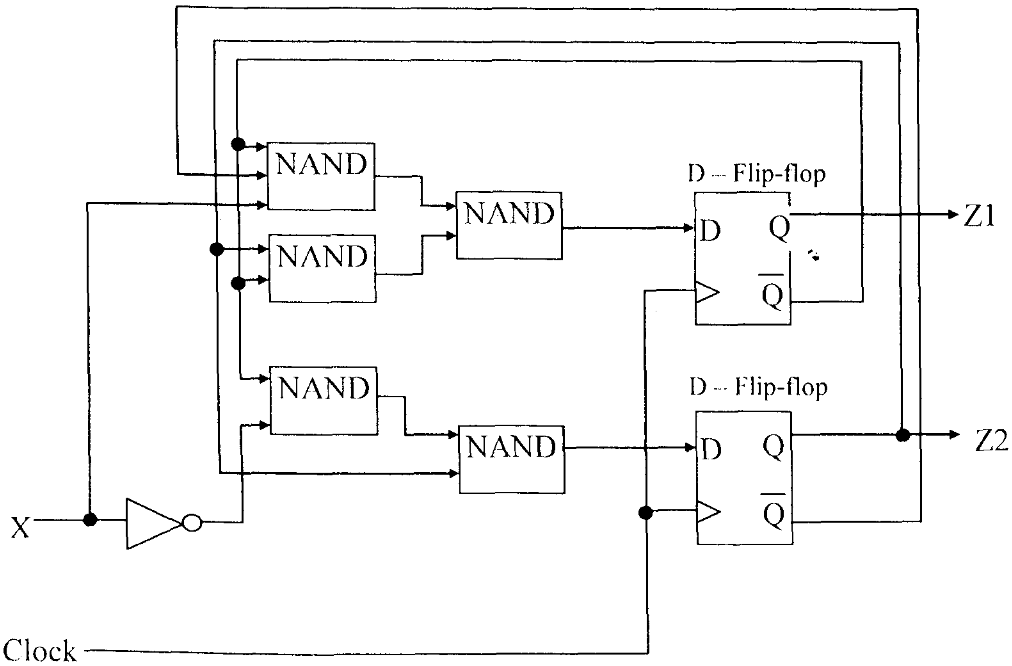
Time: 3 hours

Name:________________________ **Roll No.:**________________________

Instructions (Read carefully)

A. Answer all questions; partial credit may be given for incomplete/incorrect answers.
B. This is an **OPEN-BOOK/OPEN-NOTES** exam.
C. Total points = 110; **maximum score =100.**

1(a). **(20 points)** Analyze the sequential circuit below as a finite state machine (FSM), that is, write the next-state and output equations, and then derive the state diagram.



(b). **(10 points)** Consider the following two floating point numbers A and B in IEEE 754 single precision format:

A: 0 0111 1111 1000 0000 0000 0000 0000 000

B: 1 1000 0000 1100 0000 0000 0000 0000 000

The result of floating point multiplication (A * B) in IEEE 754 single precision format is:

2. **(10 points)** The memory location whose address in Hex is ABCDEF00, contains the MIPS instruction: 0000 1000 0000 0000 0000 0000 0000 0011, which is currently being executed. What is address of the next instruction (write the complete 32-bit address in binary or Hex)?

3. **(5 points)** For each of the statements below, write True (**T**) or False (**F**):

(i) Multi-cycle implementation of data paths for processor design improves the CP value of the computer compared to that of single cycle implementation.
(ii) In multi-cycle processor implementation, the clock cycle time is determined b the longest delay in executing an instruction.
(iii) One of the purposes of using cache memory in a computer is to enhance th memory capacity of the system.
(iv) Victim cache is provided to reduce miss rate.
(v) The rationale of LRU eviction policy in a cache is based on the principle o spatial locality.

4. **(25 points)** Consider two MIPS-based machines M1 and M2, with the following parameters:
(i) M1: cache is direct-mapped with four-word blocks; miss rate for instruction – 2%, for data 5%; miss penalty – 10 cycles; clock cycle time – 2 ns.
(ii) M2: cache is two-way set associative with four-word blocks; miss rate for instruction – 2%, fo data – 4%; miss penalty – 10 cycles; clock cycle time – 2.4 ns.

(a) A program P has 1000 instructions, and 50% instructions need data references. For P, the idea CPI for the two machines = 2.0. Compute the CPU time for running P on M1 and M2.

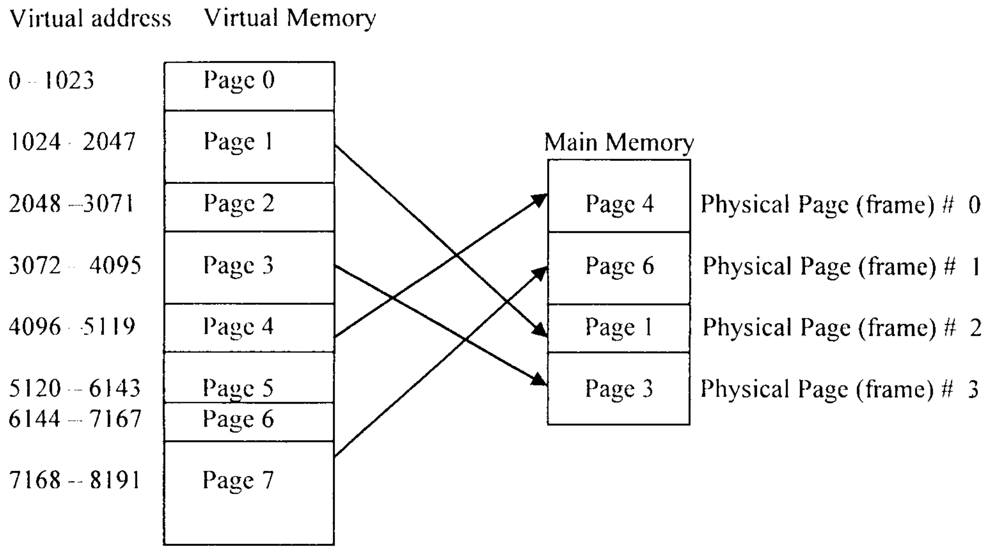
(b) In both M1 and M2, assume that the cache consists of 64 four-word blocks; 1 word = 32 bit The main memory consists of 1 K words.

(i) Compute the total size of the cache in M1 in terms of the number of bits; assume writ through cache.

(ii) Compute the total size of the cache in M2 in terms of the number of bits; assume write-back cache with dirty bits.

[8+(8+9

5. **(10 points)** A virtual memory system has 8 virtual pages each consisting of 1 K words. The physical memory (main memory) has 4 page frames of size 1 K words each. The address range of the main memory lies within {0 – 4095}, and its contents at some instant of time are shown below:



A. Encircle the virtual addresses shown below that will cause a *page fault*:

(i) 2000, (ii) 2050, (iii) 4000, (iv) 7000, (v) 8000.

B. The physical address (in decimal) corresponding to the virtual address 1034 is (choose one):

(i) 1034, (ii) 2058, (iii) 3082, (iv) 6154, (v) none of these. [5+5]

6. **(5 points)** A computer system has a memory hierarchy with virtual addressing scheme, a physically-addressed cache, and a translation-lookaside buffer (TLB). During execution of a program there is a TLB read miss.

The next action will be (choose one and justify your answer):

(i) translate the virtual address to physical address using the page table;
(ii) upload the required portion of the page table to the TLB;
(iii) evict some page from the page table and upload the requested page from secondary memory to main memory;
(iv) send the virtual address to the cache controller to check for a cache hit/miss;
(v) none of the above.

7. **(25 points)** Consider the following code sequence running on a conventional MIPS five-stage pipelined machine with CCT (including pipeline overhead) = 10 ns:

```
Loop: lw $t2, 100 ($t3)
      addi $t3, $t3, 4
      beq  $t3, $t4 Loop
      sw $t3, 100($t4)
```

(i) Assume that the initial contents of $t3 and $t4 are such that the loop will be taken 10 times. Identify and classify the hazard if any, and calculate how much time will be needed to execute the code in the absence of any special hardware arrangement like forwarding, earlier zero-testing or others.

(ii) Rewrite and reorder the code to make use of the delay slot technique, and recalculate the execution time. Assume forwarding hardware is available, and zero-testing is done as usual after the execution stage. [10+15]

INDIAN STATISTICAL INSTITUTE

Semestral Examination: 2013-2014

Course: M. Tech (CS) I

Subject: Introduction to Programming

Date: 18/11/2013 Maximum Marks: 100 Duration: 3 hours

Answer all questions. Follow ANSI C.

1. Find the correct statement in each of the following:

   I. The keyword 'case' is followed by?
      a) Float values
      b) Character values
      c) Integer values
      d) Both (b) and (c)

   II. #define abc(e,f) e##f
      a) Syntax error
      b) Run time error
      c) Valid Statement
      d) Both b and c

   III. Which among the following is right?
      a) sizeof(struct stemp*) > sizeof(union utemp*) > sizeof(char *)
      b) sizeof(struct stemp*) < sizeof(union utemp*) < sizeof(char *)
      c) sizeof(struct stemp*) = sizeof(union utemp*) = sizeof(char *)
      d) The order depends on the compiler

   IV. realloc(ptr, 0)
      a) Allocate a memory location with zero length
      b) Free the memory pointed to by ptr
      c) Undefined behavior
      d) Syntax error

   V. Assume size of double = 8, float = 4 and void = 1.

```
#include <stdio.h>
#define PI 3.14
int main()
{
  printf("%d", sizeof(PI));
}
```

      a) Output is 8
      b) Output is 4
      c) Output is 1
      d) Error, we can't use sizeof on macro-definitions

05x02 = 10

2. How does use of the void *vp in C allow a form of polymorphism? Give an example function declaration using the void *vp.

04

3. What will be the output of the following C codes?

   I.

```
#include <stdio.h>
int main()
{
  int iC = 2 ^ 3;
  printf("%d\n", iC);
}
```

II.

```
#include <stdio.h>
int main()
{
   unsigned int uiA = 10;
   uiA = ~ uiA;
   printf("%d\n", uiA);
}
```

02x02 = 04

4. Write a program in C which will take a C source code in command line and will calculate the frequency of the reserve words used in it.

30

5. Find the maximum of 10 numbers without using any loops.

10

6. Answer in short:
   a. Use printf function to print the following text on the screen:
      "Semesteral weightage is 50%!"
   b. Write predefined FILE pointers in C?
   c. Can the % operator be applied on any Data Type in C?
   d. register int iX;
      Is it possible to take the address the address iX?
   e. The correspondence between indexing and pointer arithmetic is very close. Is there any difference between an array name and a pointer?
   f. If ptr is a pointer to a structure, ptr—>mem_name refers to a particular member of that structure. Is there any other way (without using —>) to access the member of that structure?
   g. Which character(s) are not allowed to be used as the first character of a C variable?

06x02 = 12

7. Write a program in C which, given two integer inputs J and K, will print the number of ways of partitioning J items in K groups.
   For example, if J = 5 and K = 3, the output would be:
   (5,0,0) (4,1,0) (3,2,0) (3,1,1) (2,2,1)

   OR

   In a telephone keypad, the digits are mapped onto the alphabet as shown below:

   In order to make their phone numbers more memorable, service providers like to find numbers that spell out some word appropriate to their business so that phone number easier to remember. For example helpline of MyWay is 1860-2669929 (1860-26MyWay).
   Write a recursive function that will generate all possible letter combinations that correspond to a given number, represented as a string of digits. For example, 723 should generate the following 36 possible letter combinations that correspond to that prefix:

PAD	PBD	PCD	QAD	QBD	QCD	RAD	RBD	RCD	SAD	SBD	SCD
PAE	PBE	PCE	QAE	QBE	QCE	RAE	RBE	RCE	SAE	SBE	SCE
PAF	PBF	PCF	QAF	QBF	QCF	RAF	RBF	RCF	SAF	SBF	SCF

30

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End Semestral Examination

M. Tech (CS) - I Year, 2013-2014 (Semester - I)

Probability and Stochastic Processes

Date : 20.11.2013 Maximum Marks : 100 Duration : 3.5 Hours

Note: The question is of 120 marks.

Answer as much as you can, but the maximum you can score is 100.

(Q1) A permutation is a one-to-one and onto function $\pi : A \rightarrow A$, where $A = \{1, 2, \ldots, n\}$. A fixed-point of a permutation is defined as an index i for which $\pi(i) = i$. A cycle of a permutation is defined as a set of indices $\{i_1, i_2, \ldots, i_k\} \in A$, $k \leq n$, such that $\pi(i_1) = i_2$, $\pi(i_2) = i_3$, ..., $\pi(i_{k-1}) = i_k$, and $\pi(i_k) = i_1$.

(i) Design a method that generates any permutation of A with equal probability $\frac{1}{n!}$. Prove your result. [5]

(ii) What is the expected number of fixed points in a random permutation? [5]

(iii) What is the expected number of cycles in a random permutation? [10]

[5+5+10=20]

(Q2) Suppose a candidate is participating in a game show. The candidate is given the choice of three doors (A, B and C) – behind one door is a car; behind the other two, goats. The candidate picks a door at random, say A, but the chosen door is not opened immediately. The host of the game show, who knows what is behind the doors, opens another door, say C, which shows a goat. The host then says to the candidate, "Do you want to pick door B?" Is it to the advantage of the candidate to switch his/her choice? Give proper arguments in favour of your answer. [8]

(Q3) Suppose that we roll ten standard six-sided dice. What is the probability that their sum will be divisible by 6, assuming that the rolls are independent? [6]

(Q4) Let $X_1, X_2, \ldots$ be a sequence of independent and identically distributed random variables and let N be a nonnegative integer-valued random variable that is independent of the sequence X_i, $i \geq 1$. Find Var $\left(\sum_{i=1}^{N} X_i \right)$. [8]

(Q5) Let X and Y be independent random variables with finite variances. Let $U = X + Y$ and $V = XY$. Deduce the condition under which U and V are uncorrelated. [8]

(Q6) The success probability of a random experiment is p. Let X_n be the number of times the experiment needs to be performed to obtain a run of n consecutive successes. Show that $E[X_n] = \sum_{k=1}^{n} p^{-k}$. [10]

(Q7) Let $G = (V, E)$ be an undirected, connected graph with $|V| = n$ and $|E| = m$. Show that G contains a bipartite subgraph with at least $m/2$ edges. [5]

[Hints: The question does not ask you to prove the result on an induced bipartite subgraph.]

(Q8) A *tournament* on a set V of n players is an orientation $T = (V, E)$ of the edges of the complete graph on the set of vertices V. Thus for every two distinct elements x and y of V, either (x, y) or (y, x) belongs to E, but not both. A simple interpretation of *tournament* is in terms of games where each distinct pair x, y, $x, y \in V$, of players play a single match; the outcome of the games are either win or loss. (x, y) is in the *tournament* if and only if x beats y.

T has the property S_k if for every set of k players there is one who beats them all.

Show that if $\binom{n}{2}(1 - 2^{-k})^{n-k} < 1$, then there is a tournament on n vertices that has the property S_k. [10]

(Q9) If X is a random variable with mean 0 and finite variance σ^2, then for any $a > 0$, show that $\Pr(X \geq a) \leq \frac{\sigma^2}{\sigma^2 + a^2}$. [10]

(Q10) (i) State and prove the weak law of large numbers. [1+4=5]

(ii) State the strong law of large numbers. [1]

(iii) Point out the mathematical difference in the statements of weak law of large numbers and strong law of large numbers. [4]

[5+1+4=10]

(Q11) Find the expected time taken by a random walk in visiting all the vertices of K_n, a complete graph on n vertices. [10]

(Q12) (i) Prove that, in a Markov chain, if one state in a communicating class is recurrent, then all states in that class are recurrent. [7]

(ii) Consider the two state (i.e. $\{0, 1\}$) Markov chain with the following transition matrix $\mathbf{P}$

$$\begin{bmatrix} p & 1-p \\ 1-p & p \end{bmatrix}$$

Find a simple expression for $P^t_{0,0}$. [8]

[7+8=15]

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Semestral Examination

M. Tech. - I Year (Semester - I)

Data and File Structures

Date : 22.11.13 | Maximum Marks : 100 | Duration : 3:00 Hours

Note : You may answer any part of any question, but maximum you can score is 100.

1. Consider a heap H. Write an efficient algorithm to delete an arbitrary element specified by its location in the tree representing the heap H. [15]

2. Consider a binary search tree, in which in addition to the standard fields (data, left and right), each node has an integer field called size, which stores the number of elements in the subtree rooted at this node. In a range query we are given two key values $x_1 \leq x_2$ and wish to return a count the number of elements in the tree whose key value x satisfies $x_1 < x \leq x_2$. Give pseudocode for this operation, and briefly explain how your algorithm works. Your algorithm should run in $O(h)$ time, where h is the height of the tree. [20]

3. Given an $n \times n$ 0-1 matrix. A sink is defined as the integer $i \leq n$ such that for each $j \neq i, A[i,j] = 0$ and $A[j,i] = 1$. Compute the bound on the number of sinks in a matrix. Design an $O(n)$ time algorithm to compute a sink (if any) in the given matrix. [5+15=20]

4. A *treap* is a data structure which is a binary tree that stores in every internal node an ordered pair $(k;p)$, where k represents a key and p a priority of that node. Moreover, the (key) values satisfy the 'binary search tree' property and the (priority) values satisfy the 'min heap' property (i.e. the priority of the parent $\leq$ the priority of the children).

   Write an algorithm to insert an element $(k;p)$ pair in a treap where the key value k is learger than all existing key values in the treap. Note that, after insertion, the tree must remain a treap. [20]

5. Consider a splay tree containing n nodes, and let $x < y < z$ be three consecutive keys in the tree (that is, y is the only key in the tree whose value is between x and z). Suppose you perform *find*(x) followed immediately by *find*(z). What is the maximum depth of node y in the resulting tree? (Recall that the depth of a node is the number of edges between the root and that node.) [10]

6. Suppose that you modify the union/find data structure so that it performs balanced unions (using tree height), but it does not perform path compression. Starting with an initial collection of n isolated sets (each containing a single element), what is the worst case total running time for a sequence of m unions and finds? (You may assume $m \leq n$.) [10]

7. Consider an insertion of the key $x = 222$ into the hash table shown in the figure below. For each of the following probing methods, indicate the sequence of table entries that would be probed, and the final location of insertion for the key. Assume that $h(x) = 2$. In each case start with the same initial table.

(a) Linear probing.

(b) Quadratic probing.

(c) Double hashing, where $g(x) = 7$.

	0	
	1	
$h(x) \rightarrow$	2	152
	3	53
	4	
	5	75
	6	436
	7	27
	8	
	9	999

[6+6+8=20]

INDIAN STATISTICAL INSTITUTE

SEMESTRAL-I EXAMINATION (2013-14)
M.TECH.(CS) I YEAR

ELEMENTS OF ALGEBRAIC STRUCTURES

Date: 25-11-2013 Maximum marks: 100 Duration: 3 hours

The paper contains 120 marks. Answer as much as you can, the maximum you can score is 100. All notation and terms are as defined during the lectures.

1. (a) Let F be a field. Prove its only ideals are (0) and F itself.
   (b) If U and V are ideals of a ring R, let UV be the set of all elements that can be written as finite sums of elements of the form uv where $u \in U$ and $v \in V$. Prove that UV is an ideal of R.
   (c) If R is a ring with identity and ϕ is a homomorphism of R onto an integral domain R' such that the kernel of ϕ is not the whole of R, prove that $\phi(1)$ is the multiplicative identity of R'.
   (d) Let R be a Euclidean ring. An element a in R is a unit if and only if $d(a) = d(1)$.
   (e) If R is an integral domain with identity, prove that any unit in $R[x]$ must already be a unit in R.

   $(8+8+8+8+8=40)$

2. (a) Let F be a field and n and m be positive integers. If $n > m$, prove that there is a homomorphism of $F^{(n)}$ onto $F^{(m)}$ with a kernel W which is isomorphic to $F^{(n-m)}$.
   (b) Let U and V be vector spaces and T is a homomorphism of U onto V with kernel W. Prove that there is a one-to-one correspondence between the subspaces of V and the subspaces of U which contain W.
   (c) Let V be a finite-dimensional vector space and let T be a homomorphism of V onto V. Prove that T must be one-to-one.
   (d) Let V be an inner product space of dimension n and suppose that $\{w_1, \ldots, w_m\}$ is an orthonormal set in V. Prove that there exists vectors $\{w_{m+1}, \ldots, w_n\}$ such that $\{w_1, \ldots, w_m, w_{m+1}, \ldots, w_n\}$ is an orthonormal set.
   (e) Let V be an inner product space and W is a subspace of V. Suppose that some $v \in V$ satisfies $\langle v, w\rangle + \langle w, v\rangle \leq \langle w, w\rangle$ for every $w \in W$. Prove that $\langle v, w\rangle = 0$ for every $w \in W$.

   $(8+8+8+8+8=40)$

3. (a) Let E be a finite extension of a field F. Show that E is an algebraic extension of F.

(b) Find a splitting field K for $f(x) = x^2 - 2x + 4$ over the rationals $\mathbb{Q}$ and determine the degree of K

(c) Let $GF(p^n)$ be the finite field containing p^n elements. Show that the mapping $\alpha \mapsto \alpha^p$ is an isomorphism of $GF(p^n)$ onto itself.

(d) Find the possible values of a such that $x^2 + x + a$ is irreducible over the field of integers modulo 7.

(e) Consider the polynomial $x^{p^n} - x$ over $\mathbb{Z}_p$, where p is a prime. Show that the roots of this polynomial form a field.

$(8 + 8 + 8 + 8 + 8 = 40)$

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Supplementary Semestral Examination

M.Tech(CS)-I Year, 2013-2014 (Semester-I)

Discrete Mathematics

Date: 16/12/2013 Maximum Marks: **100** Duration: **3 Hour**

1. (a) Let S be a subset of $\{1, 2, \ldots, 200\}$ containing 101 elements. Prove that there are at least two integers S such that one of them is divisible by the other.

   (b) Let n be any positive integer and $\phi(n)$ be the Euler function. Then prove that

   $$\phi(n) = n \prod_{i=1}^{k}(1 - \frac{1}{p_i})$$

   where $n = p_1^{\alpha_1} p_2^{\alpha_2} \cdots p_k^{\alpha_k}$ and $p_1, p_2, \cdots, p_k$ are distinct primes..

   (c) Prove that $\forall n \in \mathbb{N}$, and $n > 1$,

   $$1 + \frac{1}{4} + \frac{1}{9} + \ldots + \frac{1}{n^2} < 2 - \frac{1}{n}$$

   (7+7+8=22

2. (a) Prove or disprove the following statements: $f(n) \notin o(g(n))$ and $f(n) \notin \omega(g(n)) \Rightarrow f(n) \in \Theta(g(n))$

   (b) Solve the following recurrence relations:

   (i) $f(0) = 3, f(1) = 17$ and $f(n) = 10f(n-1) - 25f(n-2)$ if $n \geq 2$.

   (ii) $T(n) = \begin{cases} 1 & \text{if } n = 0; \\ 3T(n-1) + 2^n & \text{if } n > 1. \end{cases}$

   (c) A computer system considers a string of decimal digits a valid codeword if it contains an even number of 0's. For instance, 1230407869 is valid, whereas 120987045608 is not valid. Let a_n be the number of valid n-digit codewords. Derive a recurrence relation for a_n.

   (6+(6+7)+7=26

3. (a) Prove that a graph G is a tree iff any two vertices of G are connected by a unique path.

   (b) A *matching* in a graph is defined as a set of edges with no two edges in the set having any common vertex. A *perfect matching* is a matching, such that every vertex in the graph has an incident edge in the matching. Let $G = (V, E)$ be an undirected graph such that $|V| = 2p$, and the degree of each vertex is at least p. Prove that G has a perfect matching.

   (6+10=16

4. (a) Prove that every planar graph is *5-colorable.*

   (b) Let G be a Eulerian graph. Prove that every vertex of G is of even degree.

   (c) Let G be a bipartite graph with q edges. Prove that $q \leq \alpha_0.\beta_0$.

   (12+6+7=25

5. (a) Prove that the proposition $p \vee \neg(p \wedge q)$ is a tautology .

   (b) Without using truth table, prove that $\neg(p \vee q) \vee (\neg p \wedge q) \equiv \neg p$.

   (5+6=1

INDIAN STATISTICAL INSTITUTE

Periodical Examination

M. Tech (CS) - I Year (Semester - II)

Design and Analysis of Algorithms

Date : February 24, 2014 Maximum Marks : 60 Duration : 3 Hours

Note : You may answer any part of any question, but maximum you can score is 60.

1. (a) Solve the recurrences: (i) $A(n) = A(n/2) + n$, and
(ii) $A(n) = A(n/2) + A(n/4) + A(n/6) + A(n/12) + n$ [Note: $1/2+1/4+1/6+1/12 = 1$]

(b) Sort the following functions from asymptotically smallest to largest, indicating ties, if any: n, $\log^* n$, $\log n$, $\log(n \log n)$, $2^{\log\log n}$, $(1 + \frac{1}{1000})^n$, $(1 - \frac{1}{1000})^n$, 2^n, 1.

[To simplify notation, write $f(n) << g(n)$ to mean $f(n) = o(g(n))$ and $f(n) \equiv g(n)$ to mean $f(n) = \Theta(g(n))$. For example, the functions $n^2, n, \binom{n}{2}, n^3$ could be sorted as follows: $n << n^2 \equiv \binom{n}{2} << n^3$.] [(4+6)+10=20]

2. A tape S contains n records, each representing a vote in an election. Each candidate for the election has a unique id. A vote for a candidate is recorded as his/her id.

   (i) Assume the number of candidates k is known apriori. Write an $O(n)$ time algorithm to find the candidate who wins the election.

   (ii) If the number of candidates k is unknown, modify your algorithm for the same problem so that your algorithm still runs in $O(n)$ time, assuming that k is very small compared to n.

   In both cases, you must mention the in-memory data structures required and justify the worst case time complexity you are claiming. [6+10=16]

3. You are given a connected undirected graph $G = (V, E)$, where the weight attached to each edge is either 1 or 2. Present an $O(|E| + |V|)$ time algorithm for computing the minimum spanning tree of the graph G. Explain the correctness of your algorithm and justify the complexity results. [10]

4. You are given an array S of n points in a 2D plane, where each point $p_i \in S$ is attached with its coordinates (x_i, y_i). The points $p_1 = (0,0)$ and $p_n = (1,0)$ are in S and the coordinates of each point p_i, $i = 2, 3, \ldots, n-1$ satisfy $0 < x_i < 1$. Write in-place algorithms for the following steps using $O(1)$ extra variables to compute the convex hull of the points in S.

   (a) Partition the points in two parts in $O(n)$ time so that the points above the x-axis form one part, and points below x-axis form the other part.

(b) Call the $O(n \log n)$ time sorting algorithm to sort the points with respect to their x-coordinates. The sorting algorithm is available as an oracle.

(c) Apply graham scan separately in both the sets of points in the two partition in in-place manner. The output for these partition will be stored in two sides of the array.

Analyze the time complexity of your proposed algorithm [4+8+3=15]

5. Show that if the Ford-Fulkersons algorithm for computing maximum flow between a pair of vertices s and t in a flow network terminates, it will produce the maximum flow value from s to t.

   Decide whether the following statement is *true* or *false*. If it is true, give proper justification, and if it is false, give a counterexample.

   > Let $G = (V, E)$ be an arbitrary flow network, with a source s and a sink t. Each edge $e \in E$ is attached with a positive integer capacity c_e. Let (A, B) be the minimum $s - t$ cut in graph G with respect to the edge costs $\{c_e, e \in E\}$. Now, if we add 1 to every edge cost, then (A, B) still remains the minimum $s - t$ cut in the revised flow network.

   [7+8 = 15]

Indian Statistical Institute

Semester-II 2013-2014

M.Tech.(CS) - First Year

Mid-term Examination (25 February, 2014)

Subject: Operating Systems

Total: 40 marks | Maximum marks: 30 | Duration: 2 hrs.

INSTRUCTIONS

1. **For each question, please mark / write your answer in the space provided after that question.**
2. **To change an answer, scratch out the old answer and write the new answer clearly. Do NOT overwrite.**
3. **You may use answer sheets only for rough work.**
4. **Please submit the answer sheets along with this question paper.**

1. Are the following statements true or false? [4 × 1 = 4]

 (a) Interrupts are synchronous events caused by peripheral devices. TRUE / FALSE

 (b) *All* processes are created via the `fork()` system call. TRUE / FALSE

 (c) Suppose that you have written a C program in a file named `hello.c`. The corresponding executable is named `a.out`.

  (i) Multiple processes may run `a.out` concurrently. TRUE / FALSE

  (ii) Multiple copies of the inode corresponding to `a.out` may exist simultaneously in the Inode table. TRUE / FALSE

2. (a) In the x86 family of processors, what does the Interrupt Descriptor Table store? How is this table accessed? [3]

 (b) Give an example of a function from the standard C library that *does not* involve a system call. Justify your answer. [3]

 (c) List the possible situations in which a context switch may occur. [3]

(d) What value does the fork() system call return? [2]

(e) Describe the typical format / structure of an executable file. [7]

(f) Recall that the passwd program may be used to change one's password. This file is owned by the root user, and has its setuid (or suid mode) bit turned on. Assume that your UID is 1001, and the UID for root is 0. What possible output can the following program generate? Clearly explain your answer. [6]

```
int main(int ac, char **av)
{
    printf("%d\n", getuid());
    execl("/usr/bin/passwd", "passwd", (char *) NULL);
    printf("%d\n", getuid());
    return 0;
}
```

3. (a) Consider a petrol pump that serves 2-wheelers, cars, and trucks. Assume that, on average,

- it takes 3, 10, and 20 minutes to serve 2-wheelers, cars, and trucks, respectively;
- 2-wheelers, cars and trucks take a total of 2, 4, and 8 minutes respectively to move into position for fuelling, and vacating the spot afterwards;
- owners / drivers of 2-wheelers have the least patience, and will leave if they are made to wait for a long time, while owners / drivers of trucks have the greatest patience.

Clearly explain the advantages / disadvantages of the following scheduling schemes in this scenario. State any additional assumptions that you need to make.

[2 + 2 + 3 = 7]

(i) Shortest-job first

(ii) Round-robin

(iii) Multi-level queue

(b) Clearly explain how the Linux 2.6 scheduler favours interactive processes over batch processes. [5]

SPACE FOR ROUGH WORK

INDIAN STATISTICAL INSTITUTE

Mid-Semester Examination: (2013-2014)

M.Tech. (CS) I Year

Database Management Systems

Date: 26.02.2014 **Maximum Marks: 60** **Duration: 2.5 Hrs.**

1. A database for a railway network has a set of trains and stations. A unique train number identifies each train. Besides the number, name of the train is also stored in the database against each train. The railway network runs four types of trains; Local, Passenger, Mail and Express. Each station also has a unique name. Number of platforms available in a station is stored in the database. Each station has different types of facilities like, refreshment room, retirement room, drinking water etc. All stations may not have all the facilities. Each station maintains the list of facilities available at that station. Against each train, its arrival and departure time against each station are also maintained in the database. Arrival time of the originating station of a train and the departure time of the final destination of a train will be assigned with a value of 9999. In all other cases, value of time is represented in terms of 24 hours.
   - From the above description draw an appropriate ER/EER diagram.
   - To design a relational schema, derive a set of relations using the standard mapping rules from the ER/EER diagram drawn.

   (10+10=20)

2. Using the relational schema designed in Question 1, form the following queries using relational algebra:
   - Find the list of trains (train-no and train-name) that originate from "Howrah" station.
   - Find the list of all stations (station-name) through which the train-no 12348 travels and have the facility of a "refreshment room".

   (10+10=20)

3. Two relations **R** and **S** are to be joined against a common attribute **a** where **a** is the primary key of **S**. Relation **R** cannot have a value of **a** that is not in **S**. Relation **R** has 10000 tuples and **S** has 2000 tuples. If for both the relations 100 tuples form a page, what would be the estimated number of disk accesses including both reading of relations and writing of results. Consider that the smaller relation can be totally accommodated in the main memory and block nested loop join is used as the join algorithm. A page for the joined relation can also accommodate 100 tuples.

   (10+10=20)

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Indian Statistical Institute

Mid-sem Examination of Second Semester (2013-2014)
M. TECH. (CS) First Year
Subject: Automata, Languages and Computation
Date: 27/02/2014 Time: 2 hours Maximum Marks: 60

Note: Notations used are as explained in the class.

1. Formally define a non-deterministic finite automaton and the language accepted by it. [8]

2. Define regular expressions over a given alphabet Σ. [6]

3. Prove or disprove the following:

$$(r+s)^* = ((r)^*(s)^*)^*.$$

where r and s are regular expressions. Here $r = s$ means $L(r) = L(s)$. $L(r)$ means language denoted by r. [8]

4. Construct a deterministic finite automaton accepting the following language: $\{w \in \{0,1\}^* : w$ has neither 00 nor 11 as a substring $\}$. [8]

5. State and prove the Pumping Lemma for regular languages. [10]

6. Show that the language

$$\{0^i 1^j : gcd(i,j) = 1\}$$

is not regular. [8]

7. Let G be the grammar

$$S \rightarrow aB|bA$$

$$S \rightarrow a|aS|bAA$$

$$S \rightarrow b|bS|aBB$$

For the string *aaabbabbba* find a
a) leftmost derivation, b) rightmost derivation, c) parse tree. [12]

Indian Statistical Institute
Mid-Semester Examination: 2014
Course Name: M. Tech in Computer Science
Subject Name: Computer Networks

Date: 28-02-2014 Maximum Marks: 60 Duration: 2 hours 30 minutes

Instructions:
You **may** attempt **all** questions which cary a total of **65** marks. However, the maximum marks you can score is only **60**.

1. (a) What is delta modulation? What are the disadvantages of delta modulation? [3 + 3]
   (b) What is scrambling technique? What are its design goals? What is the result of scrambling the sequence 1 1 0 0 0 0 0 0 0 0 1 1 using $B8ZS$ scrambling technique? Assume that the last voltage pulse preceding the octet of eight zeros was positive. [2+2+2]
   (c) For the bit stream 0 1 0 0 1 1 0 0, sketch the waveforms for each of the following encoding scheme:
      i. $NRZ - L$.
      ii. Differential Manchester. [2+2]
2. (a) Compare the performance of the *bus*, *ring* and *star* topologies with respect to cabling requirement and link failure. [3]
   (b) System A consists of a single ring with 300 stations. System B consists of three 100-station rings linked by a bridge. If the probability of a link failure is P_l, a station failure is P_s, and a bridge failure is 0, derive an expression for each of the following:
      i. Probability of failure of system A.
      ii. Probability of complete failure of system B. [2+2]
3. (a) What is spectral efficiency? [2]
   (b) What is the difference between a *hub* and a *switch*? [3]
   (c) Consider a channel with a 1 MHz capacity and an SNR of 63. What is the upper limit to the date rate that the channel can carry? How many signal levels are needed to achieve this data rates? [3]
   (d) Consider a cable where signal is attenuated at a rate of $-0.3\ dB/km$. If the signal at the beginning of that cable has a power of 2 mW, what is the power of the signal (in mW) at 5 km? [3]
4. (a) Can the generator polynomial x^4+x^2+x+1 in CRC detect all odd-numbered errors? Justify your answer. Can the generator polynomial x^6+1 in CRC detect all burst errors of length 7? Justify your answer. [2+2]
   (b) What is byte stuffing? What problems might arise with this type of framing method and how are they solved? [2+2]
   (c) How many check bits are needed to ensure that the receiver can detect and correct single bit errors using Hamming code? Show that the Hamming code

actually achieves the theoretical limit for minimum number of check bits to do 1-bit error-correction. [2+6]

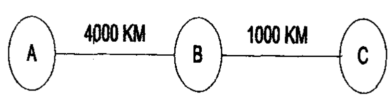
(d) The data bits 1100, 1011, 0111, 0101 are organized in rows and columns of a 4×4 matrix. The parity (even) bits of the rows, columns and entire matrix are calculated and appended to the matrix in such a way that the parity bits together with the data bits form a 5×5 matrix, as shown below. This 5×5 matrix is then transmitted to the receiver, row by row. Assume that only the data bits may be in error, not the parity bits. The receiver will recompute the parity bits and based on these values determine errors, if any. Describe the type of errors that cannot be detected with this approach. [4]

				Row parity bits	
1	1	0	0	0	
1	0	1	1	1	
0	1	1	1	1	
0	1	0	1	0	
0	1	0	1	0	Parity bit of entire matrix
Column parity bits					

5. (a) A sliding-window protocol with selective repeat is using 7 bits to represent the sequence numbers. What is the size of the window? [2]

(b) In sliding-window protocol with go-back-N, the size of the sender window must be less than 2^m, where m is the number of bits used for the representation of sequence numbers. Show in an example, by drawing a message sequence, why the size of the sender window must be less than 2^m. [3]

(c) In following figure, frames are generated at node A and sent to node C through node B. Determine the minimum transmission rate (in *kbps*) required between nodes B and C so that the buffers at node B are not flooded, based on the following:



i. The data rate between A and B is 100 *kbps*.
ii. The propagation delay is 5 *msec/km* for both lines.
iii. There are *full-duplex*, *error-free* lines between the nodes.
iv. All data frames are 1000 bits long; *ACK* frames are *separate frames of negligible length.*
v. Between A and B, a *sliding-window* protocol is used, with a *window size* of 3 (three).
vi. Between B and C, *stop and wait* protocol is used.

[6]

INDIAN STATISTICAL INSTITUTE

SEMESTRAL-I BACK PAPER EXAMINATION (2013-14)
M.TECH.(CS) I YEAR

ELEMENTS OF ALGEBRAIC STRUCTURES

Date: 01.04.14 Maximum marks: 100 Duration: 3 hours

The paper contains 100 marks. Each question carries 10 marks. Answer all questions.

1. Let m and n be positive integers such that $\gcd(m, n) = 1$. Show that given any two integers a and b, there exists an integer x such that $x \equiv a \bmod m$ and $x \equiv b \bmod n$.

2. Let S_3 be the group of all permutations of the set $\{a, b, c\}$. In S_3 show that there are two elements x and y such that $(x \cdot y)^2 \neq x^2 \cdot y^2$.

3. Let G be any group and g a fixed element of G. Define $\phi : G \to G$ by $\phi(x) = gxg^{-1}$. Prove that ϕ is an isomorphism of G onto G.

4. Give an example of an integral domain which is of positive characteristic, but, has an infinite number of elements.

5. If R is a ring with identity 1 and ϕ is a homomorphism of R *onto* R', prove that $\phi(1)$ is the identity of R'.

6. Find the greatest common divisor of the following polynomials over the field of rational numbers.
$$x^2 + 1 \text{ and } x^6 + x^3 + x + 1.$$

7. Let F be the field of real numbers and let V be the set of all sequences $(a_1, a_2, \ldots, a_n, \ldots)$, $a_i \in F$, where equality, addition and scalar multiplication are defined componentwise. Prove that V is a vector space over F.

8. If F is the field of real numbers, prove that the vectors $(1, 1, 0, 0)$, $(0, 1, -1, 0)$ and $(0, 0, 0, 3)$ in F^4 are linearly independent over F.

9. Let V be an inner product space and $\{w_1, \ldots, w_m\}$ is an orthonormal set in V. Show that
$$\sum_{i=1}^{m} |\langle w_i, v\rangle| \leq \|v\|^2 \qquad \text{for any } v \in V.$$

10. Show that the polynomial $\tau(x) = x^3 + x + 1$ is irreducible over F_2, the field of two elements. Write down the elements of $F_2[x]/(\tau(x))$.

INDIAN STATISTICAL INSTITUTE

Back Paper Examination

M. Tech (CS) - I Year, 2013-2014 (Semester - I)

Probability and Stochastic Processes

Date: 08-04-2014 | Maximum Marks: 100 | Duration: 3.5 Hours

Note: The question is of 120 marks.

Answer as much as you can, but the maximum you can score is 100.

(Q1) You are given that at least one of the events A_r, $1 \leq r \leq n$, is certain to occur, but certainly no more than two occur. If $\Pr(A_r) = p$, and $\Pr(A_r \cap A_s) = q$, $r \neq s$, show that $p \geq \frac{1}{n}$ and $q \leq \frac{2}{n}$. [10]

(Q2) Each member of a group of n players rolls a die. For any pair of players who throw the same number, the group scores 1 point. Find the mean and variance of the total score of the group. [4+6=10]

(Q3) Of the $2n$ people in a given collection of n couples, exactly m die. Assuming that the m have been picked at random, find the mean number of surviving couples. [10]

(Q4) **(i)** Let X and Y be independent discrete random variables, and let $g, h : \mathbb{R} \to \mathbb{R}$. Show that $g(X)$ and $h(Y)$ are independent. [4]

(ii) Let X and Y be independent Bernoulli random variables with parameter $\frac{1}{2}$. Show that $X + Y$ and $|X - Y|$ are dependent though uncorrelated. [6]

[4+6=10]

(Q5) Let X be a random variable with mean μ and continuous distribution function F. Show that $\int_{-\infty}^{a} F(x)dx = \int_{a}^{\infty}[1 - F(x)]dx$, if and only if $a = \mu$. [10]

(Q6) x per cent of the surface of a sphere is coloured black and the rest is white. Find an upper bound on x such that irrespective of the manner in which the colours are distributed, it is possible to inscribe a cube in the sphere with all its vertices white. [10]

(Q7) Suppose that if you are s minutes early for an appointment, then you incur the cost cs, and if you are s minutes late, then you incur the cost ks. Suppose that the travel time to the appointment venue is a continuous random variable having probability density function f. Determine the time at which you should start if you want to minimize your expected cost. [10]

(Q8) Let X and Y have joint density function $f(x, y) = 2e^{-x-y}, 0 < x < y < \infty$.

(i) Are they independent? [4]

(ii) Find their marginal density functions. [4]

(iii) Find the covariance of X and Y. [2]

[4+4+2=10]

(Q9) A set of 200 people, consisting of 100 men and 100 women, is randomly divided into 100 pairs of 2 each. Give an upper bound to the probability that at most 30 of these pairs will consist of a man and a woman. [10]

(Q10) If X and Y are independent binomial random variables with identical parameters n and p, calculate the conditional expected value of X, given that $X + Y = m$. [10]

(Q11) **(i)** Define moment generating function of a random variable X. [2]

(ii) Compute the moment generating function of a chi-squared random variable with n degrees of freedom. [8]

[2+8=10]

(Q12) Consider an infinite random walk on the integer line starting from 0. Show that the expected number of times that such a walk visits 0 is unbounded. [10]

[Hints: You can use Stirling's approximation: $n! \approx \left(\frac{n}{e}\right)^n \sqrt{2\pi n}$]

INDIAN STATISTICAL INSTITUTE

Back Paper Examination

M. Tech (CS) - I Year, 2013-2014 (Semester - I)

Probability and Stochastic Processes

Date: 08 - 04 - 2014 Maximum Marks: 100 Duration: 3.5 Hours

Note: The question is of 120 marks.

Answer as much as you can, but the maximum you can score is 100.

(Q1) You are given that at least one of the events A_r, $1 \leq r \leq n$, is certain to occur, but certainly no more than two occur. If $\Pr(A_r) = p$, and $\Pr(A_r \cap A_s) = q$, $r \neq s$, show that $p \geq \frac{1}{n}$ and $q \leq \frac{2}{n}$. [10]

(Q2) Each member of a group of n players rolls a die. For any pair of players who throw the same number, the group scores 1 point. Find the mean and variance of the total score of the group. [4+6=10]

(Q3) Of the $2n$ people in a given collection of n couples, exactly m die. Assuming that the m have been picked at random, find the mean number of surviving couples. [10]

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(ii) Let X and Y be independent Bernoulli random variables with parameter $\frac{1}{2}$. Show that $X + Y$ and $|X - Y|$ are dependent though uncorrelated. [6]

[4+6=10]

(Q5) Let X be a random variable with mean μ and continuous distribution function F. Show that $\int_{-\infty}^{a} F(x)dx = \int_{a}^{\infty} [1 - F(x)]dx$, if and only if $a = \mu$. [10]

(Q6) x per cent of the surface of a sphere is coloured black and the rest is white. Find an upper bound on x such that irrespective of the manner in which the colours are distributed, it is possible to inscribe a cube in the sphere with all its vertices white. [10]

(Q7) Suppose that if you are s minutes early for an appointment, then you incur the cost cs, and if you are s minutes late, then you incur the cost ks. Suppose that the travel time to the appointment venue is a continuous random variable having probability density function f. Determine the time at which you should start if you want to minimize your expected cost. [10]

(Q8) Let X and Y have joint density function $f(x, y) = 2e^{-x-y}, 0 < x < y < \infty$.

(i) Are they independent? [4]

(ii) Find their marginal density functions. [4]

(iii) Find the covariance of X and Y. [2]

[4+4+2=10]

(Q9) A set of 200 people, consisting of 100 men and 100 women, is randomly divided into 100 pairs of 2 each. Give an upper bound to the probability that at most 30 of these pairs will consist of a man and a woman. [10]

(Q10) If X and Y are independent binomial random variables with identical parameters n and p, calculate the conditional expected value of X, given that $X + Y = m$. [10]

(Q11) **(i)** Define moment generating function of a random variable X. [2]

(ii) Compute the moment generating function of a chi-squared random variable with n degrees of freedom. [8]

[2+8=10]

(Q12) Consider an infinite random walk on the integer line starting from 0. Show that the expected number of times that such a walk visits 0 is unbounded. [10]

[Hints: You can use Stirling's approximation: $n! \approx \left(\frac{n}{e}\right)^n \sqrt{2\pi n}$]

INDIAN STATISTICAL INSTITUTE

Semestral Examination

M. Tech (CS) - I Year (Semester - II)

Design and Analysis of Algorithms

Date : April 21, 2014 Maximum Marks : 100 Duration : 4 Hours

Note : You may answer any part of any question, but maximum you can score is 100.

1.(a) Given three sets of points A, B and C, each of size n, lying on three horizontal lines $y = 0$, $y = 1$ and $y = 2$ respectively. Design an $O(n^2)$ time algorithm to test whether there exists at least one triple (a, b, c), $a \in A$, $b \in B$ and $c \in C$ such that the points a, b and c are collinear.

(b) Suppose that (i) $A \leq_P B$ (problem A reduces in polynomial time to problem B) and the reduction runs in $O(n^2)$ time, and (ii) problem B can be solved in $O(n^4)$ time. What can you infer about the time needed to solve problem A? (Explain briefly.)

[10+10=20]

2. Suppose we are given a set $W = \{w_1, w_2, \ldots, w_n\}$ of n integers. We need to partition them into two groups X and Y, $X, Y \subseteq W$, $X \cap Y = \emptyset$ such that

$$\frac{\max(\sum_{w \in X} w, \sum_{w \in Y} w)}{\min(\sum_{w \in X} w, \sum_{w \in Y} w)}$$

is minimized. Write a dynamic programming algorithm whose time complexity is polynomial in n and $\sum_{w \in W} w$.

[15]

3.(a) In a *simple network* each node has either indegree 1 or outdegree 1.

Consider a simple *unit capacity* network. Show that the distance ℓ between the source s and the sink t cannot exceed $\frac{|V|}{f}$, where V is the set of vertices in the network and f is the value of the maximum flow.

(b) In the context of designing an algorithm for computing the maximum matching for a non-bipartite graph, the following result is important: *If at some stage of augmenting the matching, there is no augmenting path from a node u, then there will never be an augmenting path from u in the subsequent stages.* Prove this statement, and state why it is important.

[10+10 = 20]

4.(a) Assume that there is a black-box routine that multiplies two 2×2 matrices using 7 scalar multiplications. Now, design a sub-cubic algorithm for multiplying two $n \times n$ matrices. You must present a stepwise algorithm along with the analysis of its time complexity and the extra space requirement (apart from the space required for the input matrices).

(b) Let $S = \{x_1, x_2, \ldots, x_n\}$ be a set of n distinct elements. $S_1, S_2, \ldots, S_k$ are k subsets of S. Each S_i is represented as a vector of length n such that $S_i[j] = 1$ if $x_j \in S_i$; otherwise $S_i[j] = 0$. The objective is to test whether there exists two subsets S_α and S_β such that $x_j \in S_\alpha \cup S_\beta$ for each $j = 1, 2, \ldots, n$. Write a sub-cubic algorithm for solving this problem with proper justification of the time complexity.

Hints: You may consider *matrix multiplication* to formulate this problem.

[10+15=25]

5. Show that the following problem is NP-complete. Remember to show (1) that it is in NP and (2) that some known NP-complete problem can be reduced to it.

Clique decision problem: Given a graph $G = (V, E)$, a *clique* is a maximal complete sub-graph $G' = (V', E')$ of G ($V' \subseteq V$ and complete subgraph has its usual meaning, i.e., every pair of vertices in V' is connected by an edges in E'), such that addition of any other vertex $v \in V$ $v \notin V'$ in V', makes the sub-graph not-complete.

The problem is, given a graph G and an integer k, to test whether there exists a clique of size k or not.

[7+8=15]

6. Consider a special case of set cover optimization problem. The input is a universal set $S = \{x_1, x_2, \ldots, x_n\}$, and a set $\Sigma = \{S_1, S_2, \ldots, S_m\}$ of subsets of S, such that $\cup_{i=1}^{m} S_i = S$. Each element in S appears in at most two subsets of Σ. The objective is to choose the minimum number of subsets from Σ such that their union covers the entire set S.

Design a polynomial time 2-factor approximation algorithm for this version of set cover problem.

[15]

Indian Statistical Institute

Semester-II 2013-2014

M.Tech.(CS) - First Year

Semestral Examination (24 April, 2014)

Subject: Operating Systems

Total: 105 marks Maximum marks: 100 Duration: 4 hrs.

Please keep your answers brief and to the point.

1. (a) Consider n processes that use the following code structure:

```
{ ... wait(mutex); critical_section(); signal(mutex); ... }
```

where `mutex` is a semaphore initialised to 1. Clearly explain how this solution satisfies the *bounded waiting* property if the semaphores are implemented using (i) busy-waiting, (ii) blocking. Use appropriate references to the implementation of the `wait()` and `signal()` functions as necessary.

(b) Once upon a time, somewhere in Africa, there was a big lake. A large herd of elephants and a pride of lions would both come to the lake to drink water, but these two sets of animals always avoided each other.

You need to write an application that uses semaphores to simulate this situation. Model each animal by a process that executes an appropriately named function (`elephant()` or `lion()`). You may assume the existence of a function named `drink()` that has the obvious significance.

Write pseudo-code for the bodies of the `elephant()` and `lion()` functions to ensure that two different types of animals are never simultaneously executing `drink()`. Full credit will only be given to solutions that are starvation free.

[(8+4) + 24 = 36]

2. (a) Consider a memory management system on a machine with a 32-bit address bus that uses a page/frame size of 2 Kbytes. Assume that each page table entry is 4 bytes long.

   (i) How many bits can be used to store additional information about a page (besides the physical address of the corresponding frame) in each page table entry?

   (ii) List and briefly explain (2-3 lines) any **three** types of such additional information that are usually stored in page table entries.

(b) What is Belady's anomaly?

(c) Explain the Additional Reference Bits approximation to the LRU page replacement algorithm.

[(2+12) + 1 + 8 = 23]

3. Consider the memory management system in the 80386 architecture.

(a) Describe the format of the 16-bit segment selector used in this system.

(b) List and describe (in 1-2 lines each) **four** important fields contained in a segment table entry.

(c) How many segments can a process' address space contain? If each segment table entry is 8 bytes, how much space will be required to store the segment table(s)?

[3 + 6 + 4 = 13]

P.T.O.

(a) Briefly explain why (i) inodes, and (ii) disk blocks are assigned numbers starting from 1 instead of 0.

(b) Explain how an inode in the inode cache can be simultaneously on a hash queue and the free list. Briefly describe a situation where this can be useful.

(c) Briefly explain how the list of free data blocks is maintained in an SVR2 filesystem. Why is an analogous structure not needed to maintain a list of free inodes?

(d) (i) What timestamps are stored in the inode for a file or directory in an SVR2 filesystem?

(ii) Suppose some of your classmates are having an argument about which of these timestamps is displayed in the output produced by the `ls -l` command. Design an "experiment" to resolve this dispute (you should describe what command(s) you will run, and explain what conclusions you can draw based on the observed output).

[(2+2) + 7 + 7 + (3+12) = 33]

Indian Statistical Institute

Semester Examination (2013-2014)
M. TECH. (CS) First Year
Subject: Automata, Languages and Computation

Date: 28/04/2014 Time: 3 hours Maximum Marks: 100

Note: Notations used are as explained in the class.

1. (a) Prove that context free languages are not closed under intersection. [8]
   (b) If M_1 is a DFA and M_2 is a PDA then define a PDA M such that $L(M) = L(M_1) \bigcap L(M_2)$. [8]
   (c) Let $L = \{ww : w \in \{0, 1\}^*\}$. Prove that L is not context free. [8]
2. (a) Formally define a single tape one-way infinite deterministic TM and the language accepted by it. [8]
   (b) Design a deterministic single tape TM that recognises the language consisting of all palindromes over the alphabet $\{a, b\}$. [8]
   (c) Prove that if M_N is a nondeterministic TM, then there is a deterministic TM M_D such that $L(M_N) = L(M_D)$. [10]
3. (a) Define recursive set and recursively enumerable set. [4]
   (b) Construct a language which is **not** recursively enumerable. [10]
   (c) Write a short note on Church's hypothesis. [4]
4. (a) Define decidable and undecidable problems. [4]
   (b) Prove that the intersection of two recursive languages is recursive. [6]
   (c) Prove that if a language L and its complement $\bar{L}$ are both recursively enumerable, then L is recursive. [8]
5. (a) When is a language $L \subset \Sigma^*$ said to belong to (i) class P, (ii) class NP? [4]
   (b) Let $L_1, L_2 \subset \Sigma^*$. When do we say that L_1 is reducible to L_2 in polynomial time? When is a language $L \subset \Sigma^*$ called NP-complete? [6]
   (c) Show that if there is an NP-complete language L such that $L \in P$, then $P = NP$. [4]

INDIAN STATISTICAL INSTITUTE
Semester Examination: (2013-2014)
M.Tech. (CS) I Year
Database Management Systems

Date: 30.04.2014 **Maximum Marks: 50** **Duration: 2.5 Hours**

1. Two decomposed relations $R_1(a,b,c,d,x,z)$ and $R_2(a,b,c,d,y)$ have been generated for a given set of attributes (a,b,c,d,x,y,z).
   Available set of functional dependencies is: $\{a \rightarrow b, bc \rightarrow x, cd \rightarrow y\}$
   a) Check and justify whether the decomposition is lossless?
   b) Check and justify whether the decomposition is dependency preserving?
   c) If lossless decomposition and/or dependency preservation conditions are not satisfied, derive a set of normalized relations against the given set of functional dependencies.
   d) Now if a multivalued dependency a ->> z is added, what would be the new set of normalized relations?

   (3+3+6+4=16)

2. Three transactions T1, T2 and T3, sharing two different data items X and Y, are executed concurrently according to the following schedule:
   T1: R(X), T3: R(Y), T2: W(X), T3: W(Y), T3: R(X), T1: R(Y), T2: W(Y).
   Where, R(Q) = read data item Q.
   W(Q) = write data item Q.
   a) Drawing a precedence graph, show whether the above schedule is conflict serializable.
   b) To examine view serializability, draw the labeled precedence graph for two data items separately and show whether they are individually view serializable.
   c) Also draw the composite labeled precedence graph to determine whether the schedule is view serializable considering both the data items together.

   (3+4+4+3=14)

3. Considering the concurrent schedule given in Question 2, determine whether the schedule is executable under two-phase locking protocol with upgrade facility?

   (8)

4. Two transactions T_0 and T_1 are executed sequentially as shown below. Both the transactions are manipulating the data item A. If a crash occurs in one of the four places (1 to 4) as indicated in the schedule, explain the recovery action the system would undertake if it follows a deferred update log maintenance strategy with standard 'redo' and 'undo' routines. Assume that the log contains a check point after the commit of T_0 and the crash at place 2 occurred before the check point is inserted, i.e. the crash at place 2 occurs between the commit and the check point.
   Schedule:

```
T0: read (A)
    A=A-1
    write(A)
    --------------------(1)
    commit
    --------------------(2)
T1: read (A)
    A=A+2
    write (A)
    --------------------(3)
    commit
    --------------------(4)
```

   (3x4=12)

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Indian Statistical Institute
Second Semestral Examination: 2013-2014
Course Name: M. Tech. in Computer Science
Subject Name: Computer Networks

Date: 03.05.14 Maximum Marks: 100 Duration: 3 hours

Instructions:

You **may** attempt **all** questions which together carry a total of **110** marks. However, the maximum marks you can score is only **100**.

1. Two stations A and C are using *CSMA/CD* to detect collision. The data rate is 10 *Mbps* for both the stations. The distance between station A and C is 2000 *meters*, and the propagation speed is 2×10^8 *meters/second*. Station A starts sending a long frame at time $t_1 = 0$; station C starts sending a long frame at time $t_2 = 3$ *microseconds*. The size of the frame is long enough to guarantee the detection of collision by both stations. Find:

   (a) the time when station C detects the collision,

   (b) the time when station A detects the collision,

   (c) the number of bits station A has sent before detecting the collision,

   (d) the number of bits station C has sent before detecting the collision.

   [2.5 + 2.5 + 2.5 + 2.5 = 10

2. A slotted *ALOHA* network transmits 200-bit frames using a shared channel with a 200 *kbps* bandwidth. Find the throughput if the system (all stations together) produces:

   (a) 1000 frames per second,

   (b) 500 frames per second. [3+3=6

3. Compare and contrast *CSMA/CD* with *CSMA/CA*. [10

4. A frame arrives at the *MAC* layer of station s just after its contention slot has passed. How long does the station s have to wait before it can start transmitting its frame over a *LAN* that uses the basic bit-map protocol? [6

5. Explain the difference between non-persistent and p-persistent *CSMA*. [4

6. List three advantages and disadvantages of datagram networks as compared to virtual circuit networks. [6

7. User A in Network 1 is sending data to user B in Network 2. User A produces a message that is 8 $KBytes$ long. Let 2 $KBytes$ and 1 $KByte$ be the largest size of the data unit the layer can pass onwards for Networks 1 and 2, respectively. Describe how the message will be transferred from user A to user B over the different networks. [6]

8. Consider a router that interconnects three subnets: Subnet 1, Subnet 2, and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17/24. Also suppose that Subnet 1 is required to support up to 63 interfaces, Subnet 2 is to support up to 95 interfaces, and Subnet 3 is to support up to 16 interfaces. Provide three network addresses (of the form a.b.c.d/x) that satisfy these constraints. [3+3+3=9]

9. Consider a subnet with prefix 128.119.40.128/26. Give an example of one IP address (of the form a.b.c.d) that can be assigned to this network. Suppose an ISP owns the block of addresses of the form 128.119.40.64/26. Suppose it wants to create four subnets from this block, with each block having the same number of IP addresses. What are the prefixes (of the form a.b.c.d/x) for the four subnets?

[2+(2+2+2+2)=10]

10. Write the purpose of the following two fields of the $IPv6$ header:

    (a) Flow label

    (b) Next header [3+3=6]

11. Describe the limitations of flooding. How can the Location Aided Routing (LAR) protocol help overcome some of these limitations? [3+7=10]

12. Describe in brief the link state method of updating routing table information. [8]

13. What is the difference between the leaky bucket algorithm and the token bucket algorithm? A computer on a 6 $Mbps$ network is regulated by a token bucket. The token bucket is filled at a rate of 1 $Mbps$. It is initially filled to capacity with 8 megabits. How long can the computer transmit at the full 6 $Mbps$? [2+3=5]

14. What is remote procedure call? [4]

15. Datagram fragmentation and reassembly are handled by IP and are invisible to TCP. Does this mean that TCP does not have to worry about data arriving in the wrong order? Justify your answer. Briefly describe the difference between TCP and UDP. [3+7=10]