2007
CS: Computer Science and Engineering

Duration : Three Hours Maximum Marks :150

Read the following instructions carefully.

1. This question paper contains 85 objective type questions. Q.1 to Q.20 carry **one** mark each and Q.21 to Q.85 carry **two** marks each.
2. Attempt all the questions.
3. Questions must be answered on **O**bjective **R**esponse **S**heet (**ORS**) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the **ORS**. **Each question has only one correct answer.** In case you wish to change an answer, erase the old answer completely.
4. Wrong answers will carry NEGATIVE marks. In Q.1 to Q.20, **0.25** mark will be deducted for each wrong answer. In Q.21 to Q.76, Q.78, Q.80, Q.82 and in Q.84, **0.5** mark will be deducted for each wrong answer. However, there is no negative marking in Q.77, Q.79, Q.81, Q.83 and in Q.85. More than one answer bubbled against a question will be taken as an incorrect response. Unattempted questions will not carry any marks.
5. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the **ORS**.
6. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.
7. Calculator is allowed in the examination hall.
8. Charts, graph sheets or tables are NOT allowed in the examination hall.
9. Rough work can be done on the question paper itself. Additionally blank pages are given at the end of the question paper for rough work.
10. This question paper contains **24** printed pages including pages for rough work. Please check all pages and report, if there is any discrepancy.

Q. 1 – Q. 20 carry one mark each.

Q.1 Consider the following two statements about the function $f(x)=|x|$:

P. $f(x)$ is continuous for all real values of x

Q. $f(x)$ is differentiable for all real values of x

Which of the following is **TRUE**?

(A) P is true and Q is false.
(B) P is false and Q is true.
(C) Both P and Q are true.
(D) Both P and Q are false.

Q.2 Let S be a set of n elements. The number of ordered pairs in the largest and the smallest equivalence relations on S are

(A) n and n (B) n^2 and n (C) n^2 and 0 (D) n and 1

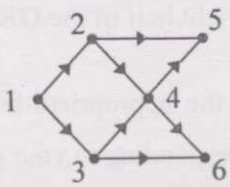
Q.3 What is the maximum number of different Boolean functions involving n Boolean variables?

(A) n^2 (B) 2^n (C) 2^{2^n} (D) 2^{n^2}

Q.4 Let G be the non-planar graph with the minimum possible number of edges. Then G has

(A) 9 edges and 5 vertices
(B) 9 edges and 6 vertices
(C) 10 edges and 5 vertices
(D) 10 edges and 6 vertices

Q.5 Consider the DAG with V = {1,2,3,4,5,6}, shown below.



Which of the following is **NOT** a topological ordering?

(A) 1 2 3 4 5 6 (B) 1 3 2 4 5 6
(C) 1 3 2 4 6 5 (D) 3 2 4 1 6 5

Q.6 Which of the following problems is undecidable?

(A) Membership problem for CFGs.
(B) Ambiguity problem for CFGs.
(C) Finiteness problem for FSAs.
(D) Equivalence problem for FSAs.

Q.7 Which of the following is **TRUE**?

(A) Every subset of a regular set is regular.
(B) Every finite subset of a non-regular set is regular.
(C) The union of two non-regular sets is not regular.
(D) Infinite union of finite sets is regular.

Q.8 How many 3-to-8 line decoders with an enable input are needed to construct a 6-to-64 line decoder without using any other logic gates?

(A) 7 (B) 8 (C) 9 (D) 10

Q.9 Consider the following Boolean function of four variables:

$$f(w,x,y,z) = \sum(1,3,4,6,9,11,12,14)$$

The function is

(A) independent of one variable.
(B) independent of two variables.
(C) independent of three variables.
(D) dependent on all the variables.

Q.10 Consider a 4-way set associative cache consisting of 128 lines with a line size of 64 words. The CPU generates a 20-bit address of a word in main memory. The number of bits in the TAG, LINE and WORD fields are respectively:

(A) 9, 6, 5 (B) 7, 7, 6 (C) 7, 5, 8 (D) 9, 5, 6

Q.11 Consider a disk pack with 16 surfaces, 128 tracks per surface and 256 sectors per track. 512 bytes of data are stored in a bit serial manner in a sector. The capacity of the disk pack and the number of bits required to specify a particular sector in the disk are respectively:

(A) 256 Mbyte, 19 bits
(B) 256 Mbyte, 28 bits
(C) 512 Mbyte, 20 bits
(D) 64 Gbyte, 28 bits

Q.12 The height of a binary tree is the maximum number of edges in any root to leaf path. The maximum number of nodes in a binary tree of height h is:

(A) $2^h - 1$ (B) $2^{h-1} - 1$ (C) $2^{h+1} - 1$ (D) 2^{h+1}

Q.13 The maximum number of binary trees that can be formed with three unlabeled nodes is:

(A) 1 (B) 5 (C) 4 (D) 3

Q.14 Which of the following sorting algorithms has the lowest worst-case complexity?

(A) Merge sort
(B) Bubble sort
(C) Quick sort
(D) Selection sort

Q.15 Consider the following segment of C-code:

```
int j, n;
  j = 1;
  while (j <= n)
      j = j*2;
```

The number of comparisons made in the execution of the loop for any $n > 0$ is:

(A) $\lceil \log_2 n \rceil + 1$ (B) n (C) $\lceil \log_2 n \rceil$ (D) $\lfloor \log_2 n \rfloor + 1$

Q.16 Group 1 contains some CPU scheduling algorithms and Group 2 contains some applications. Match entries in Group 1 to entries in Group 2.

Group 1	Group 2
P. Gang Scheduling	1. Guaranteed Scheduling
Q. Rate Monotonic Scheduling	2. Real-time Scheduling
R. Fair Share Scheduling	3. Thread Scheduling

(A) P-3; Q-2; R-1
(B) P-1; Q-2; R-3
(C) P-2; Q-3; R-1
(D) P-1; Q-3; R-2

Q.17 Consider the following statements about user level threads and kernel level threads. Which one of the following statements is **FALSE**?

(A) Context switch time is longer for kernel level threads than for user level threads.
(B) User level threads do not need any hardware support.
(C) Related kernel level threads can be scheduled on different processors in a multi-processor system.
(D) Blocking one kernel level thread blocks all related threads.

Q.18 Which one of the following is a top-down parser?

(A) Recursive descent parser.
(B) Operator precedence parser.
(C) An LR(k) parser.
(D) An LALR(k) parser.

Q.19 In Ethernet when Manchester encoding is used, the bit rate is:

(A) Half the baud rate.
(B) Twice the baud rate.
(C) Same as the baud rate.
(D) None of the above.

Q.20 Which one of the following uses UDP as the transport protocol?

(A) HTTP (B) Telnet (C) DNS (D) SMTP

Q. 21 to Q. 75 carry two marks each.

Q.21 How many different non-isomorphic Abelian groups of order 4 are there?

(A) 2 (B) 3 (C) 4 (D) 5

Q.22 Let *Graph(x)* be a predicate which denotes that x is a graph. Let *Connected(x)* be a predicate which denotes that x is connected. Which of the following first order logic sentences **DOES NOT** represent the statement: "*Not every graph is connected*"?

(A) $\neg\forall x\,(Graph(x) \Rightarrow Connected(x))$
(B) $\exists x\,(Graph(x) \wedge \neg Connected(x))$
(C) $\neg\forall x\,(\neg Graph(x) \vee Connected(x))$
(D) $\forall x\,(Graph(x) \Rightarrow \neg Connected(x))$

Q.23 Which of the following graphs has an Eulerian circuit?

(A) Any k-regular graph where k is an even number.
(B) A complete graph on 90 vertices.
(C) The complement of a cycle on 25 vertices.
(D) None of the above.

Q.24 Suppose we uniformly and randomly select a permutation from the 20! permutations of $1,2,3,\ldots,20$. What is the probability that 2 appears at an earlier position than any other even number in the selected permutation?

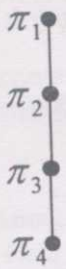
(A) $\frac{1}{2}$
(B) $\frac{1}{10}$
(C) $\frac{9!}{20!}$
(D) None of the above.

Q.25 Let A be a 4×4 matrix with eigenvalues $-5,-2,1,4$. Which of the following is an eigenvalue of $\begin{bmatrix} A & I \\ I & A \end{bmatrix}$, where I is the 4×4 identity matrix?

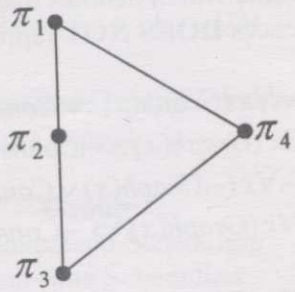
(A) -5 (B) -7 (C) 2 (D) 1

Q.26 · Consider the set $S=\{a,b,c,d\}$. Consider the following 4 partitions π_1,π_2,π_3,π_4 on S: $\pi_1=\{\overline{abcd}\}, \pi_2=\{\overline{ab},\overline{cd}\}, \pi_3=\{\overline{abc},\overline{d}\}, \pi_4=\{\overline{a},\overline{b},\overline{c},\overline{d}\}$. Let $\prec$ be the partial order on the set of partitions $S'=\{\pi_1,\pi_2,\pi_3,\pi_4\}$ defined as follows: $\pi_i \prec \pi_j$ if and only if π_i refines π_j. The poset digram for $(S',\prec)$ is

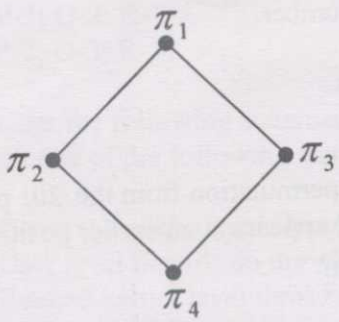
(A)



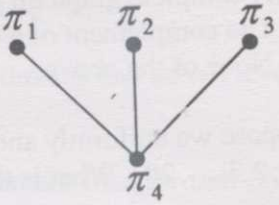
(B)



(C)



(D)



Q.27 Consider the set of (column) vectors defined by $X=\{x\in R^3 \mid x_1+x_2+x_3=0$, where $x^T=[x_1,x_2,x_3]^T\}$. Which of the following is **TRUE**?

(A) $\{[1,-1,0]^T,[1,0,-1]^T\}$ is a basis for the subspace X.

(B) $\{[1,-1,0]^T,[1,0,-1]^T\}$ is a linearly independent set, but it does not span X and therefore is not a basis of X.

(C) X is not a subspace of R^3.

(D) None of the above.

Q.28 Consider the series $x_{n+1}=\frac{x_n}{2}+\frac{9}{8x_n}$, $x_0=0.5$ obtained from the Newton-Raphson method. The series converges to

(A) 1.5 (B) $\sqrt{2}$ (C) 1.6 (D) 1.4

Q.29 A minimum state deterministic finite automaton accepting the language $L=\{w \mid w\in\{0,1\}^*$, number of 0s and 1s in w are divisible by 3 and 5, respectively$\}$ has

(A) 15 states (B) 11 states (C) 10 states (D) 9 states

Q.30 The language $L = \{ 0^i21^i \mid i \geq 0 \}$ over the alphabet {0, 1, 2} is

(A) not recursive.
(B) is recursive and is a deterministic CFL.
(C) is a regular language.
(D) is not a deterministic CFL but a CFL.

Q.31 Which of the following languages is regular?

(A) $\left\{ ww^R \middle| w \in \{0,1\}^+ \right\}$

(B) $\left\{ ww^R x \middle| x, w \in \{0,1\}^+ \right\}$

(C) $\left\{ wxw^R \middle| x, w \in \{0,1\}^+ \right\}$

(D) $\left\{ xww^R \middle| x, w \in \{0,1\}^+ \right\}$

Q.32 Let $f(w,x,y,z) = \sum(0,4,5,7,8,9,13,15)$. Which of the following expressions are **NOT** equivalent to f ?

(P) $x'y'z'+w'xy'+wy'z+xz$
(Q) $w'y'z'+wx'y'+xz$
(R) $w'y'z'+wx'y'+xyz+xy'z$
(S) $x'y'z'+wx'y'+w'y$

(A) P only
(B) Q and S
(C) R and S
(D) S only

Q.33 Define the connective * for the Boolean variables X and Y as: $X * Y = XY + X'Y'$. Let $Z = X * Y$. Consider the following expressions P, Q and R.

$P: X = Y * Z$ $\quad Q: Y = X * Z$ $\quad R: X * Y * Z = 1$

Which of the following is **TRUE**?

(A) Only P and Q are valid.
(B) Only Q and R are valid.
(C) Only P and R are valid.
(D) All P, Q, R are valid.

Q.34 Suppose only one multiplexer and one inverter are allowed to be used to implement any Boolean function of n variables. What is the minimum size of the multiplexer needed?

(A) 2^n line to 1 line
(B) 2^{n+1} line to 1 line
(C) 2^{n-1} line to 1 line
(D) 2^{n-2} line to 1 line

Q.35 In a look-ahead carry generator, the carry generate function G_i and the carry propagate function P_i for inputs A_i and B_i are given by:

$$P_i = A_i \oplus B_i \text{ and } G_i = A_i B_i$$

The expressions for the sum bit S_i and the carry bit C_{i+1} of the look-ahead carry adder are given by:

$$S_i = P_i \oplus C_i \text{ and } C_{i+1} = G_i + P_i C_i, \text{ where } C_0 \text{ is the input carry.}$$

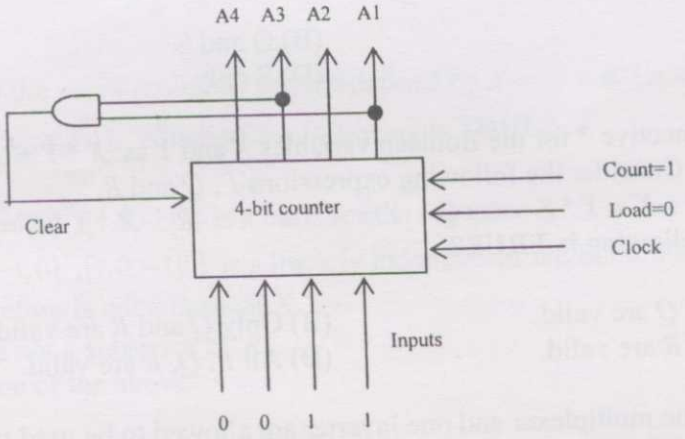
Consider a two-level logic implementation of the look-ahead carry generator. Assume that all P_i and G_i are available for the carry generator circuit and that the AND and OR gates can have any number of inputs. The number of AND gates and OR gates needed to implement the look-ahead carry generator for a 4-bit adder with S_3, S_2, S_1, S_0 and C_4 as its outputs are respectively:

(A) 6, 3 (B) 10, 4 (C) 6, 4 (D) 10, 5

Q.36 The control signal functions of a 4-bit binary counter are given below (where X is "don't care"):

Clear	Clock	Load	Count	Function
1	X	X	X	Clear to 0
0	X	0	0	No change
0	↑	1	X	Load input
0	↑	0	1	Count next

The counter is connected as follows:



Assume that the counter and gate delays are negligible. If the counter starts at 0, then it cycles through the following sequence:

(A) 0, 3, 4 (B) 0, 3, 4, 5
(C) 0, 1, 2, 3, 4 (D) 0, 1, 2, 3, 4, 5

Q.37 Consider a pipelined processor with the following four stages:

IF: Instruction Fetch
ID: Instruction Decode and Operand Fetch
EX: Execute
WB: Write Back

The IF, ID and WB stages take one clock cycle each to complete the operation. The number of clock cycles for the EX stage depends on the instruction. The ADD and SUB instructions need 1 clock cycle and the MUL instruction needs 3 clock cycles in the EX stage. Operand forwarding is used in the pipelined processor. What is the number of clock cycles taken to complete the following sequence of instructions?

ADD	R2, R1, R0	R2 ← R1 + R0
MUL	R4, R3, R2	R4 ← R3 * R2
SUB	R6, R5, R4	R6 ← R5 – R4

(A) 7 (B) 8 (C) 10 (D) 14

Q.38 The following postfix expression with single digit operands is evaluated using a stack:

8 2 3 ^ / 2 3 * + 5 1 * –

Note that ^ is the exponentiation operator. The top two elements of the stack after the first * is evaluated are:

(A) 6,1 (B) 5,7 (C) 3,2 (D) 1,5

Q.39 The inorder and preorder traversal of a binary tree are

d b e a f c g and a b d e c f g, respectively.

The postorder traversal of the binary tree is

(A) d e b f g c a
(B) e d b g f c a
(C) e d b f g c a
(D) d e f g b c a

Q.40 Consider a hash table of size seven, with starting index zero, and a hash function $(3x+4) \bmod 7$. Assuming the hash table is initially empty, which of the following is the contents of the table when the sequence 1,3,8,10 is inserted into the table using closed hashing? Note that – denotes an empty location in the table.

(A) 8,–,–,–,–,–,10
(B) 1,8,10,–,–,–,3
(C) 1,–,–,–,–,–,3
(D) 1,10,8,–,–,–,3

Q.41 In an unweighted, undirected connected graph, the shortest path from a node S to every other node is computed most efficiently, in terms of *time complexity*, by

(A) Dijkstra's algorithm starting from S.
(B) Warshall's algorithm.
(C) performing a DFS starting from S.
(D) performing a BFS starting from S.

Q.42 Consider the following C function:

```
int f(int n)
{static int r=0;
 if (n <= 0) return 1;
 if (n > 3)
    {r = n;
     return f(n-2)+2;
    }
 return f(n-1)+r;
}
```

What is the value of `f(5)`?

(A) 5 (B) 7 (C) 9 (D) 18

Q.43 A complete n-ary tree is a tree in which each node has n children or no children. Let I be the number of internal nodes and L be the number of leavés in a complete n-ary tree. If $L = 41$, and $I = 10$, what is the value of n?

(A) 3 (B) 4 (C) 5 (D) 6

Q.44 In the following C function, let $n \geq m$.

```
int gcd(n,m)
{
  if(n%m == 0) return m;
  n = n%m;
  return gcd(m,n);
}
```

How many recursive calls are made by this function?

(A) $\Theta(\log_2 n)$ (B) $\Omega(n)$ (C) $\Theta(\log_2 \log_2 n)$ (D) $\Theta(\sqrt{n})$

Q.45 What is the *time complexity* of the following recursive function:

```
int DoSomething (int n){
   if (n <= 2)
      return 1;
   else
       return(DoSomething(floor(sqrt(n))) + n);
}
```

(A) $\Theta(n^2)$ (B) $\Theta(n \log_2 n)$ (C) $\Theta(\log_2 n)$ (D) $\Theta(\log_2 \log_2 n)$