Q.1 – Q.30: Section 1 (Carry ONE Mark Each)
Q.1 – Q.20: MCQ (1/6 Negative Marking)

Q.1 You are given an array of n integers arranged in increasing order. Suppose one of these integers is changed (either increased or decreased). Which of the following sorting algorithms can be used to sort this modified array in $O(n)$ time?

(A) Quicksort

(B) Mergesort

(C) Insertion sort

(D) Heapsort

Q.2 You run quicksort on an array consisting of n elements. In your implementation, the first element in the array is chosen as the pivot element. When you run the algorithm, it so happens that in each recursive call on a sub-array, the chosen pivot element partitions the sub-array in the ratio 1: 2. Which of the following expression correctly captures the recurrence relation for the running time, $T(n)$, of the quicksort algorithm in this specific case (ignore the base case)?

(A) $T(n) = T\left(\frac{n}{3}\right) + T\left(\frac{2n}{3}\right) + O(n)$

(B) $T(n) = 2T\left(\frac{n}{3}\right) + O(n)$

(C) $T(n) = 2T\left(\frac{2n}{3}\right) + O(n)$

(D) $T(n) = 2T\left(\frac{n}{2}\right) + O(n)$

Q.3 You are given a set of data points $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$ in the two-dimensional plane. Using linear regression, you want to fit a line $y = ax + b$ to these points. Which of the following expressions is the objective function which needs to be minimized for this purpose?

(A) $\sum_{i=1}^{n} (y_i - ax_i - b)$

(B) $\sum_{i=1}^{n} (y_i - ax_i - b)^2$

(C) $\sum_{i=1}^{n} |y_i - ax_i - b|$

(D) $\sum_{i=1}^{n} (y_i - ax_i + b)^2$

Q.4 A network protocol *P* detects packet corruption using checksums. *P* uses packet retransmissions if checksum fails. *P* ensures correct packet ordering at destination, and also does flow control by using sliding window sizes. What is *P*?

(A) IP

(B) UDP

(C) TCP

(D) CSMA

Q.5 The Boolean expression $(a \vee (\bar{a} \wedge b))$, where a and b are Boolean variables, simplifies to:

(A) a

(B) $\bar{a}$

(C) $a \vee b$

(D) $\bar{a} \vee b$

Q.6 In a positive edge-triggered D flip-flop, with data input D, clock input Clk, and outputs Q and $\bar{Q}$, we have $D = 1, Clk = 1, Q = 1$, and $\bar{Q} = 0$ at a given time. After the value of Clk changes to 0 at a later time, what are the resulting values at the outputs?

(A) $Q = 1, \bar{Q} = 0$

(B) $Q = 0, \bar{Q} = 0$

(C) $Q = 1, \bar{Q} = 1$

(D) $Q = 0, \bar{Q} = 1$

Q.7 Consider a processor with a single 5-stage pipeline executing a sequence of n instructions with no branches. If each pipeline stage executes in 1 clock cycle, the minimum number of clock cycles required for executing the instruction sequence is

(A) $5n$

(B) $n + 4$

(C) $5n + 4$

(D) n

Q.8 A computer system has a cache of size C bytes, main memory of size M bytes, register file of size R bytes, and disk of size D bytes. The most common relation between these quantities is

(A) $C < M < R < D$

(B) $C < R < M < D$

(C) $R < C < M < D$

(D) $R < M < C < D$

Q.9 Let Q be a first-in-first-out queue. The method *enqueue(x)* adds element *x* to the end of Q and the method *dequeue()* removes and returns the element at the front of Q. Suppose Q is initially empty and we perform operations *Q.enqueue(a), Q.enqueue(b), Q.enqueue(c), Q.dequeue(), Q.enqueue(d), Q.dequeue().* The element returned by the last *dequeue()* operation is

(A) *a*

(B) *b*

(C) *c*

(D) *d*

Q.10 The language $\{a^i \mid i = 3k + 5, k \geq 0 \text{ and } k \text{ is an integer}\}$ is

(A) regular

(B) not regular but context free

(C) not context free but recursive

(D) not recursive

Q.11 A binary min-heap with n elements can be viewed as a binary tree T on n nodes. For a node v in T, let $v.\text{key}$ denote the value of the element associated with v and $v.\text{parent}$ be the parent of v. Let r be the root of T. Which of the following statements is NOT necessarily true?

(A) All levels of T, except the last level are full.

(B) $v.\text{key} \geq v.\text{parent.key}$ for all v in T, $v \neq r$.

(C) $r.\text{key} \leq v.\text{key}$ for all v in T.

(D) If v has 2 children then $v.\text{left.key} \leq v.\text{right.key}$ where $v.\text{left}$ is the left-child and $v.\text{right}$ is the right-child of v.

Q.12 Consider the following Table T in a relational database. What is the output of the SQL query

```
Select distinct name, section from T where
course='CS101';
```

name	id	course	section
abcd	1	CS101	2
bcde	2	CS101	1
cdef	3	CS102	1
abcd	4	CS102	2
bcde	5	CS101	1
defg	6	CS102	2

(A)
```
abcd 2
bcde 1
bcde 1
```

(B)
```
abcd CS101 2
bcde CS101 1
bcde CS101 1
```

(C)
```
abcd 2
bcde 1
```

(D)
```
abcd 1 CS101 2
bcde 1 CS101 1
bcde 5 CS101 1
```

Q.13 Which of the following is NOT a standard database indexing structure?

(A) B+ tree index

(B) Hash index

(C) BCNF index

(D) Bitmap index

Q.14 Given the declaration "`int x`" , the JAVA expression

```
x == 2 || x >= 4
```

evaluates to the same result as

(A) `x != 3`

(B) `x > 1 && x != 3`

(C) `x != 2 || x < 4`

(D) `x/2 >= 1`

Q.15 In Java two or more methods with the same name may exist in the same file

(A) only if they have different signatures

(B) only if they have different scope

(C) only if they are in different packages

(D) only if they have different scopes or different signatures

Q.16 You are typing in a Microsoft Word document while listening to music on the Windows media player on the same computer. Which of the following statements is correct?

(A) the computer need not have any processor, as none of the two programs do any computation

(B) a single core CPU can run both programs, although the music player may experience lags

(C) the computer must have dual core CPU

(D) both CPU and GPU must be present in the computer

Q.17 A DNS server contains

(A) only IP addresses

(B) only Internet Domain Names

(C) (IP address, Internet Domain Name) pairs

(D) host MAC addresses

Q.18 Consider an n-sided convex polygon in the plane. A line segment in this plane which is not parallel to any side of the convex polygon intersects the boundary of the polygon

(A) at least $n - 2$ times

(B) exactly two times

(C) at least one time

(D) 0, 1, or 2 times

Q.19 How many different virtual memory addresses are possible with 24 address bits?

(A) 16 K

(B) 16 M

(C) 64 T

(D) 16 P

Q.20 Operating Systems use Page Table for

(A) Process Scheduling

(B) Process Synchronization

(C) Memory Management

(D) Interrupt Handling

Q.21 – Q.30: MSQ/NAT (No Negative Marking)

Q.21 Virtual methods in Java -

(A) are not methods at all

(B) are private methods

(C) cannot be inherited

(D) are resolved at execution time

Q.22 Which of the following is/are combinational circuit(s)?

(A) Multiplexer

(B) D Flip-flop

(C) AND gate

(D) J-K Flip-flop

Q.23 Which of the following computer components is/are example(s) of an I/O device?

(A) CPU

(B) Cache memory

(C) Keyboard

(D) Monitor

Q.24 Consider a connected undirected graph G with distinct edge weights. Let C be a cycle and e be an edge in C. Which of the following statements about minimum spanning tree(s) of G must be true?

(A) If e is the minimum weight edge in C, then there is a minimum spanning tree in G containing e.

(B) If e is the minimum weight edge in C, then every minimum spanning tree in G must contain e.

(C) If e is the maximum weight edge in C, then there cannot be any minimum spanning tree in G containing e.

(D) If e is the maximum weight edge in C, then there is a minimum spanning tree in G which does not contain e.

Q.25 In the waterfall model for software development, which of the following statements is/are correct?

(A) The requirement analysis and specification step is performed before the design step.

(B) The design step is performed before the requirement analysis and specification step.

(C) The feasibility study step is performed before the design step.

(D) The feasibility study step is performed after the requirement analysis and specification step.

Q.26 The minimum number of bits required for representing all integers between and including –16 and +16 using 2's complement representation is _____.

Q.27 Let $a_0, a_1, a_2, \ldots, a_i, \ldots$ be a sequence defined by $a_i = 2a_{i-2}, a_0 = 1, a_1 = \sqrt{2}$. The value of a_{10} (*in integer*) is _____.

Q.28 The number of times the method B is called in the JAVA code fragment below as a result of the call "`A(50)`" is _____.

```
int B(int x) {
    if(x > 0) return A(x+1);
    return 0;
}
int A(int x) {
    if(x > 0) return B(x-2);
    return 0;
}
```

Q.29 LRU page replacement is used with 4 page frames and 8 pages, numbered 0 through 7. Assume the 4 frames are initially empty. The number of page faults for the page request sequence 0, 1, 7, 2, 3, 2, 7, 1, 0, 3 is _____.

Q.30 Consider a program with a serial portion that requires 10 ns, and a fully parallelizable portion that completes in 20 ns on a single processor computer. If we run this program on a parallel computer with 10 processors, the minimum possible execution time (in ns, *in integer*) is _____.

Q.31 – Q.50: Section 2 (Carry TWO Marks Each)
Q.31 – Q.40: MCQ (2/6 Negative Marking)

Q.31 Which of the following statements is true?

(A) Entity-relationship data model is equivalent to Relational data model

(B) A relational database cannot support object based data model

(C) Every record in a relational database table must have the same number of attributes

(D) Every record in a semi-structured data model must have the same number of attributes

Q.32 In the IEEE Standard 754 floating point representation, which number is represented by sign bit S, exponent bits E, and fraction bits F?

(A) $S \times 2^E \times F$

(B) $S \times E \times (1 + F)$

(C) $(-1)^S \times 2^E \times (1 + F)$

(D) $(-1)^S \times 2^E \times F$

Q.33 You are given an unlimited supply of coins of denomination Rs 1, Rs 5, Rs 7, Rs 11. Given a non-negative integer n, the problem is to find **exact** change for Rs n. The greedy algorithm for this problem can be described as follows: find the largest denomination coin with value at most n. Use such a coin, and now recursively find the change for the balance amount. When $n = 109$, how many coins will the greedy algorithm use?

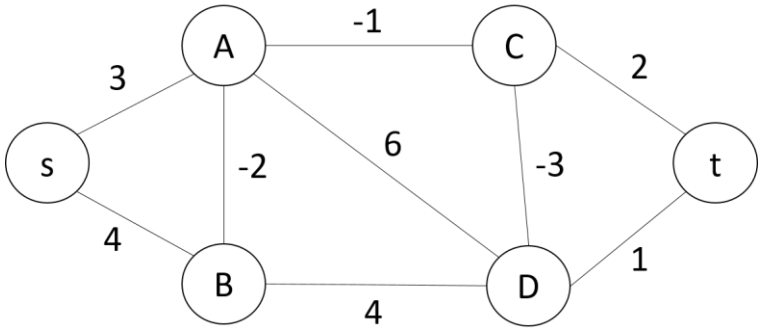
(A) 10

(B) 11

(C) 12

(D) 13

Q.34 Consider the following undirected graph with edge weights specified in the figure. Suppose we run Dijkstra's algorithm on this graph from the source node s. When the algorithm terminates, what will be the distance label of the node t?



(A) 9

(B) –1

(C) 4

(D) 0

Q.35 We are given two vectors P_1 and P_2 representing points p_1 and p_2, respectively, in the Euclidean plane. Which of the following does NOT represent the line through p_1 and p_2? Here t is a real parameter.

(A) $(1-t)P_1 + tP_2$

(B) $tP_1 + tP_2$

(C) $P_1 + t(P_1 - P_2)$

(D) $½(1-t)P_1 + ½(1+t)P_2$

Q.36 A context free grammar with start symbol S, terminal set $\{a, b, c\}$, non-terminal set $\{S, X, Y\}$ has productions $\{S \rightarrow aXbbYc,\ \ X \rightarrow aXb \mid \epsilon,\ \ Y \rightarrow bYc \mid \epsilon\}$ where ϵ is the null-string. The language generated by this grammar is

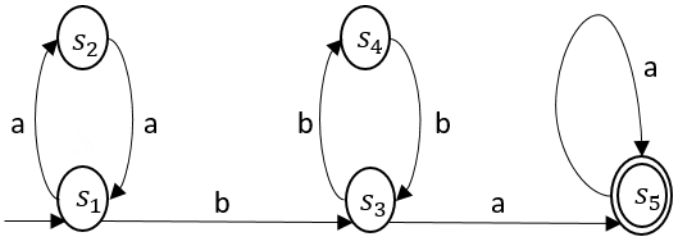
(A) $\{a^i b^j c^k \mid i, j, k \geq 1\}$

(B) $\{a^i b^j c^k \mid i = j = k,\ \ i, j, k \geq 1\}$

(C) $\{a^i b^j c^k \mid i, k \geq 1, j = i + k\}$

(D) $\{a^i b^{2i} c^i \mid i \geq 1\}$

Q.37 The DFA shown in the figure has start state s_1 and final state s_5. The language accepted by the DFA is



(A) $\{a^i b^{2j-1} a^k \mid i, j, k \geq 1\}$

(B) $\{a^{2i} b^{2j+1} a^{k+1} \mid i, j, k \geq 0\}$

(C) $\{a^{2i} b^{2j-1} a^k \mid i, j, k \geq 1\}$

(D) $\{a^{2i} b^{2j+1} a^k \mid i, j, k \geq 0\}$

Q.38 What is the value printed on executing `A.main` in the following JAVA code?

```
class A {
   int color = 50;
   void m(A a) {
      a.color --;
   }

   public static void main(String agv[]) {
      A a = new A();
      a.m(new A());
      System.out.println(a.color);
   }
}
```

(A) 50

(B) 49

(C) 0

(D) Cannot be determined as `a` is undefined

Q.39 Which of the following is NOT true for a map-reduce system?

(A) Map function takes a single (key, value) pair and returns 0 or more such pairs

(B) Reduce function takes multiple values associated with the same key and generates a single value for that key

(C) every Reduce function call is preceded by a Map function call

(D) Reduce function sorts the (key, value) list produced by Map function

Q.40 Your program in the file main.c uses printf and scanf functions, which are defined in the static library /usr/lib/libc.a. Which system software ensures that the appropriate functions are called at runtime?

(A) compiler

(B) loader

(C) linker

(D) debugger

Q.41 – Q.50: MSQ/NAT (No Negative Marking)

Q.41 Public key cryptography can provide the following security service(s):

(A) message authentication

(B) message integrity

(C) message confidentiality

(D) malware detection

Q.42 Which of the following Boolean functions is/are represented by the Karnaugh Map below?

a \ bc	00	01	11	10
0	1	1	1	0
1	0	1	0	0

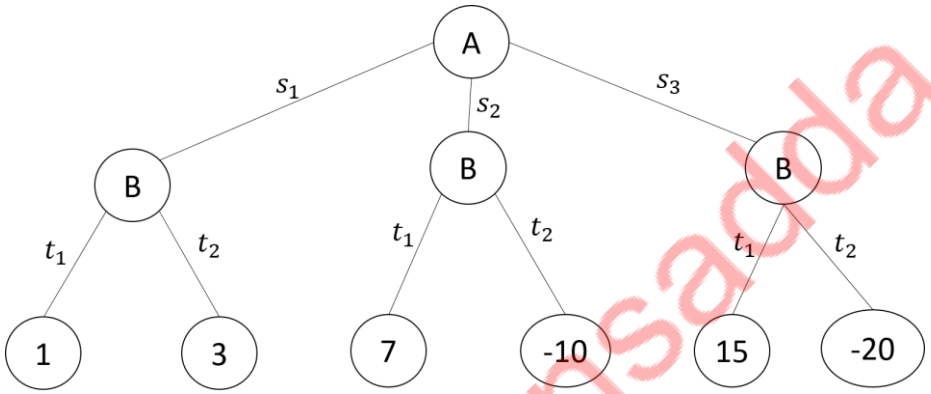
(A) $(\bar{a} \wedge \bar{b} \wedge \bar{c}) \vee (\bar{b} \wedge c)$

(B) $(a \wedge b \wedge c) \vee (\bar{b} \wedge \bar{c})$

(C) $(\bar{a} \wedge \bar{b}) \vee (\bar{a} \wedge c) \vee (\bar{b} \wedge c)$

(D) $(\bar{a} \wedge \bar{b}) \vee (\bar{a} \wedge c) \vee (a \wedge \bar{b} \wedge c)$

Q.43 Two players A and B play a game – A plays first, then B plays its move, after which the game ends. A has three strategies (s_1, s_2, s_3) and B has two strategies (t_1, t_2). The numbers at the leaf nodes in the game tree below denote the money paid by B to A (a negative value denotes money paid by A to B). A wants to maximize the money obtained from B, and similarly B wants to minimize the money paid to A. Assuming both players play their optimal strategy, the amount of money A will win in this game (*in integer*) is _____.



Q.44 You are given two bags: bag A and bag B. Bag A has 3 red and 5 green balls. Bag B has 3 red and 4 green balls. You pick a bag uniformly at random and select a ball uniformly at random from this bag. The chosen ball turns out to be red. The probability that you had chosen bag A (*rounded off to two decimal places*) is _____.

Q.45 The keys {1,2,3,4,5,6,7,8,9,10} are inserted in an empty binary search tree in the order: $3, 5, 6, 2, 9, 10, 8, 7, 1, 4$. If no rotations are performed during insertion, the key which is the furthest from the root is _____.

Q.46 The value of A[5] at the end of the execution of the following JAVA code fragment (*in integer*) is _____.

```
int[] A =  {2, 7, 5, 8, 9, 3};

for(int i=0; i < A.length; i++)
    if(A[i] < A[A.length-i-1])
              A[i] = A[A.length-i-1]+1;
```

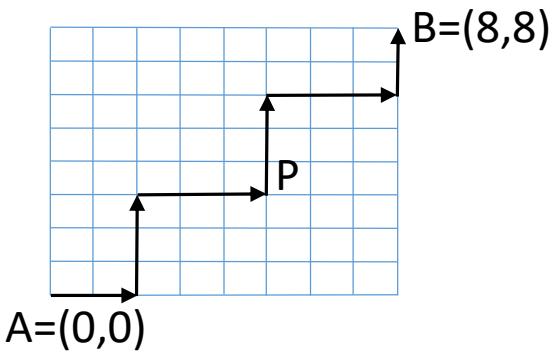
Q.47 The value of `sum` at the end of the execution of the following JAVA code fragment (*in integer*) is _____.

```
int[] A = {0, 1, 2, 3, 4, 5, 6};
int sum = 0;

for(int i=0; i < A.length; i+=2)
    for(int j=0; j<i; j++)
         if(A[i] < 4 && (j % 2 == 0)) sum += A[j];
```

Q.48 Five batch jobs A through E arrive at a computer center at the same time. They have running times of 10, 6, 2, 4 and 8 minutes. Their (externally determined) priorities are 3, 5, 2, 1, 4 respectively, with 5 being highest priority. The mean process turnaround time (in minutes, *in integer*) with priority scheduling without pre-emption is _____.

Q.49 Shyam has to move from A to B on an 8×8 grid by following the grid lines. In the figure below, A is at $(0,0)$ and B at $(8,8)$ and P is a path with 3 left turns and 2 right turns. Shyam can start moving RIGHT or UP from point A and this is not counted as a turn.



The number of paths from A to B involving exactly one left and exactly one right turn (left and right turns can be in any order) is _____.

Q.50 I have a bag with 6 balls numbered 1 to 6, another bag with 8 balls numbered 1 to 8 and a third bag with 10 balls numbered 1 to 10. I pick a ball uniformly at random from each bag and sum the numbers on the 3 balls picked. Let $1/a$ be the probability that the sum is 4. Then a (*in integer*) is _____.