GATE 2014: General Instructions during Examination

1. Total duration of the GATE examination is **180** minutes.
2. The clock will be set at the server. The countdown timer at the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You need not terminate the examination or submit your paper.
3. Any useful data required for your paper can be viewed by clicking on the **Useful Common Data** button that appears on the screen.
4. Use the scribble pad provided to you for any rough work. Submit the scribble pad at the end of the examination.
5. You are allowed to use a non-programmable type calculator, however, sharing of calculators is not allowed.
6. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:

1	You have not visited the question yet.
3	You have not answered the question.
5	You have answered the question.
7	You have NOT answered the question, but have marked the question for review.
9	You have answered the question, but marked it for review.

The **Marked for Review** status for a question simply indicates that you would like to look at that question again. *If a question is answered, but marked for review, then the answer will be considered for evaluation unless the status is modified by the candidate.*

Navigating to a Question :

7. To answer a question, do the following:
    a. Click on the question number in the Question Palette to go to that question directly.
    b. Select an answer for a multiple choice type question by clicking on the bubble placed before the 4 choices, namely A, B, C and D. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
    c. Click on **Save & Next** to save your answer for the current question and then go to the next question.
    d. Click on **Mark for Review & Next** to save your answer for the current question and also mark it for review, and then go to the next question.

Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on a question number without saving the answer to the previous question.

You can view all the questions by clicking on the **Question Paper** button. This feature is provided, so that if you want you can just see the entire question paper at a glance.

Answering a Question :

8. Procedure for answering a multiple choice (MCQ) type question:
   a. Choose one answer from the 4 options (A,B,C,D) given below the question, click on the bubble placed before the chosen option.
   b. To deselect your chosen answer, click on the bubble of the chosen option again or click on the **Clear Response** button.
   c. To change your chosen answer, click on the bubble of another option.
   d. To save your answer, you MUST click on the **Save & Next** button.

9. Procedure for answering a numerical answer type question:
   a. To enter a number as your answer, use the virtual numerical keypad.
   b. A fraction (e.g. -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point. As many as four decimal points, e.g. 12.5435 or 0.003 or -932.6711 or 12.82 can be entered.
   c. To clear your answer, click on the **Clear Response** button.
   d. To save your answer, you MUST click on the **Save & Next** button

10. To mark a question for review, click on the **Mark for Review & Next** button. *If an answer is selected (for MCQ) or entered (for numerical answer type) for a question that is **Marked for Review**, that answer will be considered in the evaluation unless the status is modified by the candidate.*

11. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.

12. Note that ONLY Questions for which answers are *saved* or *marked for review after answering* will be considered for evaluation.

Choosing a Section :

13. Sections in this question paper are displayed on the top bar of the screen. Questions in a Section can be viewed by clicking on the name of that Section. The Section you are currently viewing will be highlighted.

14. A checkbox is displayed for every optional Section, if any, in the Question Paper. To select the optional Section for answering, click on the checkbox for that Section.

15. If the checkbox for an optional Section is not selected, the **Save & Next** button and the **Mark for Review & Next** button will NOT be enabled for that Section. You will

only be able to see questions in this Section, but you will not be able to answer questions in the Section.

16. After clicking the **Save & Next** button for the last question in a Section, you will automatically be taken to the first question of the next Section in sequence.

17. You can move the mouse cursor over the name of a Section to view the answering status for that Section.

Changing the Optional Section :

18. After answering the chosen optional Section, partially or completely, you can change the optional Section by selecting the checkbox for a new Section that you want to attempt. A warning message will appear along with a table showing the number of questions answered in each of the previously chosen optional Sections and a checkbox against each of these Sections. Click on a checkbox against a Section that you want to reset and then click on the **RESET** button. Note that RESETTING a Section will DELETE all the answers for questions in that Section. Hence, if you think that you may want to select this Section again later, you will have to note down your answers for questions in that Section. If you do not want to reset the Section and want to continue answering the previously chosen optional Section, then click on the **BACK** button.

19. If you deselect the checkbox for an optional Section in the top bar, the following warning message will appear: "Deselecting the checkbox will DELETE all the answers for questions in this Section. Do you want to deselect this Section?" If you want to deselect, click on the **RESET** button. If you do not want to deselect, click on the **BACK** button.

20. You can shuffle between different Sections or change the optional Sections any number of times.

GATE 2014 Examination

CS: Computer Science & Information Technology

Duration: **180 minutes**   *Maximum Marks*: **100**

Read the following instructions carefully.

1. To login, enter your Registration Number and password provided to you. Kindly go through the various symbols used in the test and understand their meaning before you start the examination.
2. Once you login and after the start of the examination, you can view all the questions in the question paper, by clicking on the **View All Questions** button in the screen.
3. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory.
   The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.
   The subject specific GATE paper section consists of **55** questions, out of which question numbers 1 to 25 are of 1-mark each, while question numbers 26 to 55 are of 2-mark each.
4. Depending upon the GATE paper, there may be useful common data that may be required for answering the questions. If the paper has such useful data, the same can be viewed by clicking on the **Useful Common Data** button that appears at the top, right hand side of the screen.

5. The computer allotted to you at the examination center runs specialized software that permits only one answer to be selected for multiple-choice questions using a mouse and to enter a suitable number for the numerical answer type questions using the virtual keyboard and mouse.
6. Your answers shall be updated and saved on a server periodically and also at the end of the examination. The examination will **stop automatically** at the end of **180 minutes**.
7. In each paper a candidate can answer a total of 65 questions carrying 100 marks.
8. The question paper may consist of questions of **multiple choice type** (MCQ) and **numerical answer type**.
9. Multiple choice type questions will have four choices against A, B, C, D, out of which only **ONE** is the correct answer. The candidate has to choose the correct answer by clicking on the bubble (○) placed before the choice.
10. For numerical answer type questions, each question will have a numerical answer and there will not be any choices**. For these questions, the answer should be entered**by using the virtual keyboard that appears on the monitor and the mouse.
11. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of⅓ marks for a 1-mark question and ⅔ marks for a 2-mark question.
12. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.

13. Non-programmable type Calculator is allowed. Charts, graph sheets, and mathematical tables are **NOT** allowed in the Examination Hall. You must use the Scribble pad provided to you at the examination centre for all your rough work. The Scribble Pad has to be returned at the end of the examination.

Declaration by the candidate:

"I have read and understood all the above instructions. I have also read and understood clearly the instructions given on the admit card and shall follow the same. I also understand that in case I am found to violate any of these instructions, my candidature is liable to be cancelled. I also confirm that at the start of the examination all the computer hardware allotted to me are in proper working condition".

Q. 1 – Q. 5 carry one mark each.

Q.1   <u>While trying to collect</u> an envelope <u>from under the table</u>, <u>Mr. X fell down</u> and
            I   II   III
        <u>was losing consciousness</u>.
           IV
        Which one of the above underlined parts of the sentence is NOT appropriate?

(A) I   (B) II   (C) III   (D) IV

Q.2   If she _____ how to calibrate the instrument, she _____ done the experiment.

(A) knows, will have   (B) knew, had
(C) had known, could have   (D) should have known, would have

Q.3   Choose the word that is opposite in meaning to the word "coherent".

(A) sticky   (B) well-connected   (C) rambling   (D) friendly

Q.4   Which number does not belong in the series below?
        2, 5, 10, 17, 26, 37, 50, 64

(A) 17   (B) 37   (C) 64   (D) 26

Q.5   The table below has question-wise data on the performance of students in an examination. The marks for each question are also listed. There is no negative or partial marking in the examination.

Q No.	Marks	Answered Correctly	Answered Wrongly	Not Attempted
1	2	21	17	6
2	3	15	27	2
3	2	23	18	3

What is the average of the marks obtained by the class in the examination?

(A) 1.34   (B) 1.74   (C) 3.02   (D) 3.91

Q. 6 – Q. 10 carry two marks each.

Q.6   A dance programme is scheduled for 10.00 a.m. Some students are participating in the programme and they need to come an hour earlier than the start of the event. These students should be accompanied by a parent. Other students and parents should come in time for the programme. The instruction you think that is appropriate for this is

(A) Students should come at 9.00 a.m. and parents should come at 10.00 a.m.
(B) Participating students should come at 9.00 a.m. accompanied by a parent, and other parents and students should come by 10.00 a.m.
(C) Students who are not participating should come by 10.00 a.m. and they should not bring their parents. Participating students should come at 9.00 a.m.
(D) Participating students should come before 9.00 a.m. Parents who accompany them should come at 9.00 a.m. All others should come at 10.00 a.m.

Q.7 By the beginning of the 20th century, several hypotheses were being proposed, suggesting a paradigm shift in our understanding of the universe. However, the clinching evidence was provided by experimental measurements of the position of a star which was directly behind our sun.

Which of the following inference(s) may be drawn from the above passage?

(i) Our understanding of the universe changes based on the positions of stars
(ii) Paradigm shifts usually occur at the beginning of centuries
(iii) Stars are important objects in the universe
(iv) Experimental evidence was important in confirming this paradigm shift

(A) (i), (ii) and (iv)   (B) (iii) only   (C) (i) and (iv)   (D) (iv) only

Q.8 The Gross Domestic Product (GDP) in Rupees grew at 7% during 2012-2013. For international comparison, the GDP is compared in US Dollars (USD) after conversion based on the market exchange rate. During the period 2012-2013 the exchange rate for the USD increased from Rs. 50/ USD to Rs. 60/ USD. India's GDP in USD during the period 2012-2013

(A) increased by 5 %   (B) decreased by 13%
(C) decreased by 20%   (D) decreased by 11%

Q.9 The ratio of male to female students in a college for five years is plotted in the following line graph. If the number of female students in 2011 and 2012 is equal, what is the ratio of male students in 2012 to male students in 2011?

(A) 1:1   (B) 2:1   (C) 1.5:1   (D) 2.5:1

Q.10 Consider the equation: $(7526)_8 - (Y)_8 = (4364)_8$, where $(X)_N$ stands for X to the base N. Find Y.

(A) 1634   (B) 1737   (C) 3142   (D) 3162

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1   Consider the following statements:

   P: Good mobile phones are not cheap
   Q: Cheap mobile phones are not good

   L: P implies Q
   M: Q implies P
   N: P is equivalent to Q

Which one of the following about L, M, and N is **CORRECT**?

(A) Only L is TRUE.

(B) Only M is TRUE.

(C) Only N is TRUE.

(D) L, M and N are TRUE.

Q.2   Let X and Y be finite sets and $f: X \to Y$ be a function. Which one of the following statements is TRUE?

(A) For any subsets A and B of X, $|f(A \cup B)| = |f(A)| + |f(B)|$

(B) For any subsets A and B of X, $f(A \cap B) = f(A) \cap f(B)$

(C) For any subsets A and B of X, $|f(A \cap B)| = \min\{|f(A)|, |f(B)|\}$

(D) For any subsets S and T of Y, $f^{-1}(S \cap T) = f^{-1}(S) \cap f^{-1}(T)$

Q.3   Let G be a group with 15 elements. Let L be a subgroup of G. It is known that $L \neq G$ and that the size of L is at least 4. The size of L is _____.

Q.4   Which one of the following statements is TRUE about every $n \times n$ matrix with only real eigenvalues?

(A) If the trace of the matrix is positive and the determinant of the matrix is negative, at least one of its eigenvalues is negative.

(B) If the trace of the matrix is positive, all its eigenvalues are positive.

(C) If the determinant of the matrix is positive, all its eigenvalues are positive.

(D) If the product of the trace and determinant of the matrix is positive, all its eigenvalues are positive.

Q.5　If V_1 and V_2 are 4-dimensional subspaces of a 6-dimensional vector space V, then the smallest possible dimension of $V_1 \cap V_2$ is _____.

Q.6　If $\int_0^{2\pi} |x \sin x| \, dx = k\pi$, then the value of k is equal to _____ .

Q.7　Consider the following minterm expression for F:

$$F(P, Q, R, S) = \sum 0, 2, 5, 7, 8, 10, 13, 15$$

The minterms 2, 7, 8 and 13 are 'do not care' terms. The minimal sum-of-products form for F is

(A) $Q\bar{S} + \bar{Q}S$

(B) $\bar{Q}\bar{S} + QS$

(C) $\bar{Q}\bar{R}\bar{S} + \bar{Q}R\bar{S} + Q\bar{R}S + QRS$

(D) $\bar{P}\bar{Q}\bar{S} + \bar{P}QS + PQS + P\bar{Q}\bar{S}$

Q.8　Consider the following combinational function block involving four Boolean variables x, y, a, b where x, a, b are inputs and y is the output.

```
f (x, y, a, b)
{
    if (x is 1) y = a;
    else y = b;
}
```

Which one of the following digital logic blocks is the most suitable for implementing this function?

(A) Full adder　　　(B) Priority encoder　(C) Multiplexor　　　(D) Flip-flop

Q.9　Consider the following processors (ns stands for nanoseconds). Assume that the pipeline registers have zero latency.

P1: Four-stage pipeline with stage latencies 1 ns, 2 ns, 2 ns, 1 ns.
P2: Four-stage pipeline with stage latencies 1 ns, 1.5 ns, 1.5 ns, 1.5 ns.
P3: Five-stage pipeline with stage latencies 0.5 ns, 1 ns, 1 ns, 0.6 ns, 1 ns.
P4: Five-stage pipeline with stage latencies 0.5 ns, 0.5 ns, 1 ns, 1 ns, 1.1 ns.

Which processor has the highest peak clock frequency?

(A) P1　　　　　　　(B) P2　　　　　　　(C) P3　　　　　　　(D) P4

Q.10 Let A be a square matrix of size $n \times n$. Consider the following pseudocode. What is the expected output?

```
C = 100;
for i = 1 to n do
  for j = 1 to n do
    {
     Temp = A[i][j] + C;
     A[i][j]= A[j][i];
     A[j][i] = Temp - C;
    }
for i = 1 to n do
  for j = 1 to n do
      output (A[i][j]);
```

(A) The matrix A itself

(B) Transpose of the matrix A

(C) Adding 100 to the upper diagonal elements and subtracting 100 from lower diagonal elements of A

(D) None of the above

Q.11 The minimum number of arithmetic operations required to evaluate the polynomial $P(X) = X^5 + 4 X^3 + 6 X + 5$ for a given value of X, using only one temporary variable is _____.

Q.12 Consider the following rooted tree with the vertex labeled P as the root:
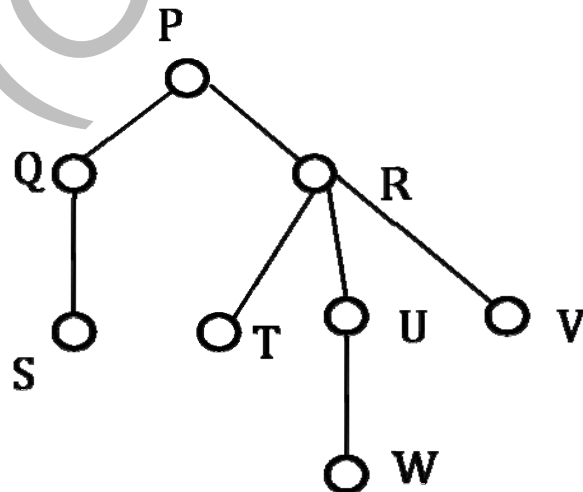
The order in which the nodes are visited during an in-order traversal of the tree is

(A) SQPTRWUV

(B) SQPTUWRV

(C) SQPTWUVR

(D) SQPTRUWV

Q.13 Suppose depth first search is executed on the graph below starting at some unknown vertex. Assume that a recursive call to visit a vertex is made only after first checking that the vertex has not been visited earlier. Then the maximum possible recursion depth (including the initial call) is _____.
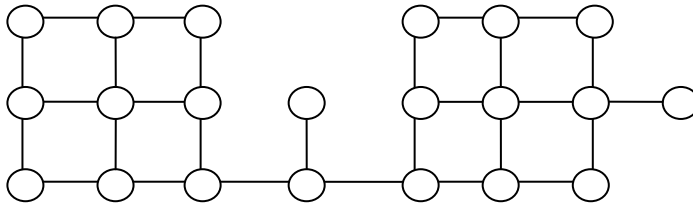
Q.14 You have an array of *n* elements. Suppose you implement quicksort by always choosing the central element of the array as the pivot. Then the tightest upper bound for the worst case performance is

(A) $O(n^2)$ (B) $O(n \log n)$ (C) $\Theta(n \log n)$ (D) $O(n^3)$

Q.15 The length of the shortest string NOT in the language (over $\Sigma = \{a, b\}$) of the following regular expression is _____.

$$a^* b^* (ba)^* a^*$$

Q.16 Let Σ be a finite non-empty alphabet and let 2^{Σ^*} be the power set of Σ^*. Which one of the following is **TRUE**?

(A) Both 2^{Σ^*} and Σ^* are countable

(B) 2^{Σ^*} is countable and Σ^* is uncountable

(C) 2^{Σ^*} is uncountable and Σ^* is countable

(D) Both 2^{Σ^*} and Σ^* are uncountable

Q.17 One of the purposes of using intermediate code in compilers is to

(A) make parsing and semantic analysis simpler.

(B) improve error recovery and error reporting.

(C) increase the chances of reusing the machine-independent code optimizer in other compilers.

(D) improve the register allocation.

Q.18　Which of the following statements are CORRECT?

1) Static allocation of all data areas by a compiler makes it impossible to implement recursion.
2) Automatic garbage collection is essential to implement recursion.
3) Dynamic allocation of activation records is essential to implement recursion.
4) Both heap and stack are essential to implement recursion.

(A) 1 and 2 only　　　(B) 2 and 3 only　　　(C) 3 and 4 only　　　(D) 1 and 3 only

Q.19　In the context of modular software design, which one of the following combinations is desirable?

(A) High cohesion and high coupling

(B) High cohesion and low coupling

(C) Low cohesion and high coupling

(D) Low cohesion and low coupling

Q.20　A system uses 3 page frames for storing process pages in main memory. It uses the Least Recently Used (**LRU**) page replacement policy. Assume that all the page frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below?

4, 7, 6, 1, 7, 6, 1, 2, 7, 2

Q.21　What is the optimized version of the relation algebra expression $\pi_{A1}(\pi_{A2}(\sigma_{F1}(\sigma_{F2}(r))))$, where $A1, A2$ are sets of attributes in r with $A1 \subset A2$ and $F1, F2$ are Boolean expressions based on the attributes in r?

(A) $\pi_{A1}(\sigma_{(F1 \wedge F2)}(r))$

(B) $\pi_{A1}(\sigma_{(F1 \vee F2)}(r))$

(C) $\pi_{A2}(\sigma_{(F1 \wedge F2)}(r))$

(D) $\pi_{A2}(\sigma_{(F1 \vee F2)}(r))$

Q.22　A *prime attribute* of a relation scheme R is an attribute that appears

(A) in all candidate keys of R.

(B) in some candidate key of R.

(C) in a foreign key of R.

(D) only in the primary key of R.

Q.23   In the following pairs of OSI protocol layer/sub-layer and its functionality, the **INCORRECT** pair is

     (A)   Network layer and Routing

     (B)   Data Link Layer and Bit synchronization

     (C)   Transport layer and End-to-end process communication

     (D)   Medium Access Control sub-layer and Channel sharing

Q.24   A bit-stuffing based framing protocol uses an 8-bit delimiter pattern of 01111110. If the output bit-string after stuffing is 01111100101, then the input bit-string is

     (A)   0111110100

     (B)   0111110101

     (C)   0111111101

     (D)   0111111111

Q.25   Host A (on TCP/IP v4 network A) sends an IP datagram D to host B (also on TCP/IP v4 network B). Assume that no error occurred during the transmission of D. When D reaches B, which of the following IP header field(s) may be different from that of the original datagram D?

       (i) TTL   (ii) Checksum   (iii) Fragment Offset

     (A)   (i) only

     (B)   (i) and (ii) only

     (C)   (ii) and (iii) only

     (D)   (i), (ii) and (iii)

Q. 26 – Q. 55 carry two marks each.

Q.26   An IP router implementing Classless Inter-domain Routing (CIDR) receives a packet with address 131.23.151.76. The router's routing table has the following entries:

Prefix	Output Interface Identifier
131.16.0.0/ 12	3
131.28.0.0/ 14	5
131.19.0.0/ 16	2
131.22.0.0/ 15	1

The identifier of the output interface on which this packet will be forwarded is _____.

Q.27   Every host in an IPv4 network has a 1-second resolution real-time clock with battery backup. Each host needs to generate up to 1000 unique identifiers per second. Assume that each host has a globally unique IPv4 address. Design a 50-bit globally unique ID for this purpose. After what period (in seconds) will the identifiers generated by a host wrap around?

Q.28   An IP router with a Maximum Transmission Unit (MTU) of 1500 bytes has received an IP packet of size 4404 bytes with an IP header of length 20 bytes. The values of the relevant fields in the header of the third IP fragment generated by the router for this packet are

(A)   MF bit: 0, Datagram Length: 1444; Offset: 370

(B)   MF bit: 1, Datagram Length: 1424; Offset: 185

(C)   MF bit: 1, Datagram Length: 1500; Offset: 370

(D)   MF bit: 0, Datagram Length: 1424; Offset: 2960

Q.29   Consider the transactions **T1**, **T2**, and **T3** and the schedules **S1** and **S2** given below.

```
T1: r1(X); r1(Z); w1(X); w1(Z)
T2: r2(Y); r2(Z); w2(Z)
T3: r3(Y); r3(X); w3(Y)

S1: r1(X); r3(Y); r3(X); r2(Y); r2(Z); w3(Y); w2(Z); r1(Z); w1(X); w1(Z)
S2: r1(X); r3(Y); r2(Y); r3(X); r1(Z); r2(Z); w3(Y); w1(X); w2(Z); w1(Z)
```

Which one of the following statements about the schedules is **TRUE**?

(A)   Only **S1** is conflict-serializable.

(B)   Only **S2** is conflict-serializable.

(C)   Both **S1** and **S2** are conflict-serializable.

(D)   Neither **S1** nor **S2** is conflict-serializable.

Q.30   Consider the relational schema given below, where **eId** of the relation **dependent** is a foreign key referring to **empId** of the relation **employee**. Assume that every employee has at least one associated dependent in the **dependent** relation.

```
employee (empId, empName, empAge)
dependent(depId, eId, depName, depAge)
```

Consider the following relational algebra query:

$$\Pi_{empId}(\texttt{employee}) - \Pi_{empId}(\texttt{employee} \bowtie_{(empId\ =\ eID) \wedge (empAge\ \leq\ depAge)} \texttt{dependent})$$

The above query evaluates to the set of **empId**s of employees whose age is greater than that of

(A)   some dependent.

(B)   all dependents.

(C)   some of his/her dependents.

(D)   all of his/her dependents.

Q.31　A system contains three programs and each requires three tape units for its operation. The minimum number of tape units which the system must have such that deadlocks never arise is _____.

Q.32　An operating system uses *shortest remaining time first* scheduling algorithm for pre-emptive scheduling of processes. Consider the following set of processes with their arrival times and CPU burst times (in milliseconds):

Process	Arrival Time	Burst Time
P1	0	12
P2	2	4
P3	3	6
P4	8	5

The average waiting time (in milliseconds) of the processes is _____.

Q.33　Consider a paging hardware with a TLB. Assume that the entire page table and all the pages are in the physical memory. It takes 10 milliseconds to search the TLB and 80 milliseconds to access the physical memory. If the TLB hit ratio is 0.6, the effective memory access time (in milliseconds) is _____.

Q.34　Consider the basic block given below.

```
a = b + c
c = a + d
d = b + c
e = d - b
a = e + b
```

The minimum number of nodes and edges present in the DAG representation of the above basic block respectively are

(A)　6 and 6　　　　(B)　8 and 10　　　　(C)　9 and 12　　　　(D)　4 and 4

Q.35　Which one of the following problems is undecidable?

(A)　Deciding if a given context-free grammar is ambiguous.

(B)　Deciding if a given string is generated by a given context-free grammar.

(C)　Deciding if the language generated by a given context-free grammar is empty.

(D)　Deciding if the language generated by a given context-free grammar is finite.

Q.36 Consider the following languages over the alphabet $\Sigma = \{0,1,c\}$:

$L_1 = \{0^n1^n \mid n \geq 0\}$
$L_2 = \{wcw^r \mid w \in \{0,1\}^*\}$
$L_3 = \{ww^r \mid w \in \{0,1\}^*\}$

Here, w^r is the reverse of the string w. Which of these languages are deterministic Context-free languages?

(A)　None of the languages

(B)　Only L_1

(C)　Only L_1 and L_2

(D)　All the three languages

Q.37 Suppose you want to move from 0 to 100 on the number line. In each step, you either move right by a unit distance or you take a *shortcut*. A shortcut is simply a pre-specified pair of integers i, j with $i < j$. Given a shortcut i, j if you are at position i on the number line, you may directly move to j. Suppose $T(k)$ denotes the smallest number of steps needed to move from k to 100. Suppose further that there is at most 1 shortcut involving any number, and in particular from 9 there is a shortcut to 15. Let y and z be such that $T(9) = 1 + \min(T(y), T(z))$. Then the value of the product yz is _____.

Q.38 Consider the decision problem *2CNFSAT* defined as follows:

$\{ \Phi \mid \Phi$ is a satisfiable propositional formula in CNF with at most two literals per clause $\}$

For example, $\Phi = (x_1 \vee x_2) \wedge (x_1 \vee \overline{x_3}) \wedge (x_2 \vee x_4)$ is a Boolean formula and it is in *2CNFSAT*.

The decision problem *2CNFSAT* is

(A)　NP-Complete.

(B)　solvable in polynomial time by reduction to directed graph reachability.

(C)　solvable in constant time since any input instance is satisfiable.

(D)　NP-hard, but not NP-complete.

Q.39 Suppose we have a balanced binary search tree T holding n numbers. We are given two numbers L and H and wish to sum up all the numbers in T that lie between L and H. Suppose there are m such numbers in T. If the tightest upper bound on the time to compute the sum is $O(n^a \log^b n + m^c \log^d n)$, the value of $a + 10b + 100c + 1000d$ is ____.

Q.40 Consider a hash table with 100 slots. Collisions are resolved using chaining. Assuming simple uniform hashing, what is the probability that the first 3 slots are unfilled after the first 3 insertions?

(A) $(97 \times 97 \times 97)/100^3$

(B) $(99 \times 98 \times 97)/100^3$

(C) $(97 \times 96 \times 95)/100^3$

(D) $(97 \times 96 \times 95)/(3! \times 100^3)$

Q.41 Consider the pseudocode given below. The function **DoSomething()** takes as argument a pointer to the root of an arbitrary tree represented by the *leftMostChild-rightSibling* representation. Each node of the tree is of type **treeNode**.

```
typedef struct treeNode* treeptr;

struct treeNode
{
        treeptr leftMostChild, rightSibling;
};

int DoSomething (treeptr tree)
{
   int value=0;
   if (tree != NULL) {
     if (tree->leftMostChild == NULL)
         value = 1;
     else
         value =  DoSomething(tree->leftMostChild);
     value = value + DoSomething(tree->rightSibling);
   }
   return(value);
}
```

When the pointer to the root of a tree is passed as the argument to **DoSomething**, the value returned by the function corresponds to the

(A) number of internal nodes in the tree.

(B) height of the tree.

(C) number of nodes without a right sibling in the tree.

(D) number of leaf nodes in the tree.

Q.42   Consider the C function given below. Assume that the array **listA** contains **n** (> 0) elements, sorted in ascending order.

```
int ProcessArray(int *listA, int x, int n)
{
  int i, j, k;
  i = 0;
  j = n-1;
  do {
      k = (i+j)/2;
      if (x <= listA[k])
          j = k-1;
      if (listA[k] <= x)
          i = k+1;
      }while (i <= j);

  if (listA[k] == x)
      return(k);
  else
      return -1;
}
```

Which one of the following statements about the function **ProcessArray** is **CORRECT**?

(A) It will run into an infinite loop when **x** is not in **listA**.

(B) It is an implementation of binary search.

(C) It will always find the maximum element in **listA**.

(D) It will return −1 even when **x** is present in **listA**.

Q.43   An instruction pipeline has five stages, namely, instruction fetch (IF), instruction decode and register fetch (ID/RF), instruction execution (EX), memory access (MEM), and register writeback (WB) with stage latencies 1 ns, 2.2 ns, 2 ns, 1 ns, and 0.75 ns, respectively (ns stands for nanoseconds). To gain in terms of frequency, the designers have decided to split the ID/RF stage into three stages (ID, RF1, RF2) each of latency 2.2/3 ns. Also, the EX stage is split into two stages (EX1, EX2) each of latency 1 ns. The new design has a total of eight pipeline stages. A program has 20% branch instructions which execute in the EX stage and produce the next instruction pointer at the end of the EX stage in the old design and at the end of the EX2 stage in the new design. The IF stage stalls after fetching a branch instruction until the next instruction pointer is computed. All instructions other than the branch instruction have an average CPI of one in both the designs. The execution times of this program on the old and the new design are P and Q nanoseconds, respectively. The value of P/Q is _____.

Q.44   The memory access time is 1 nanosecond for a read operation with a hit in cache, 5 nanoseconds for a read operation with a miss in cache, 2 nanoseconds for a write operation with a hit in cache and 10 nanoseconds for a write operation with a miss in cache. Execution of a sequence of instructions involves 100 instruction fetch operations, 60 memory operand read operations and 40 memory operand write operations. The cache hit-ratio is 0.9. The average memory access time (in nanoseconds) in executing the sequence of instructions is _____.

Q.45
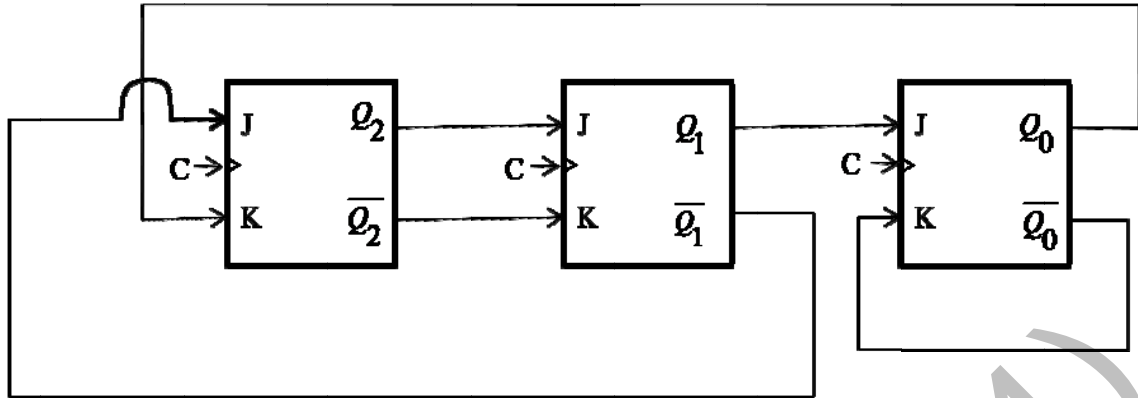
The above synchronous sequential circuit built using JK flip-flops is initialized with $Q_2Q_1Q_0 = 000$. The state sequence for this circuit for the next 3 clock cycles is

(A) 001, 010, 011

(B) 111, 110, 101

(C) 100, 110, 111

(D) 100, 011, 001

Q.46   With respect to the numerical evaluation of the definite integral, $K = \int_a^b x^2\, dx$, where a and b are given, which of the following statements is/are TRUE?

   I)   The value of K obtained using the trapezoidal rule is always greater than or equal to the exact value of the definite integral.
   II)   The value of K obtained using the Simpson's rule is always equal to the exact value of the definite integral.

   (A) I only   (B) II only   (C) Both I and II   (D) Neither I nor II

Q.47   The value of the integral given below is

$$\int_0^\pi x^2 \cos x\, dx$$

   (A) -2π (B) π (C) $-\pi$ (D) 2π

Q.48   Let S be a sample space and two mutually exclusive events A and B be such that $A \cup B = S$. If $P(\cdot)$ denotes the probability of the event, the maximum value of $P(A)P(B)$ is _____.

Q.49　Consider the set of all functions $f: \{0, 1, \ldots, 2014\} \rightarrow \{0, 1, \ldots, 2014\}$ such that $f(f(i)) = i$, for all $0 \le i \le 2014$. Consider the following statements:

P. For each such function it must be the case that for every i, $f(i) = i$.
Q. For each such function it must be the case that for some i, $f(i) = i$.
R. Each such function must be onto.

Which one of the following is CORRECT?

(A)　P, Q and R are true

(B)　Only Q and R are true

(C)　Only P and Q are true

(D)　Only R is true

Q.50　There are two elements x, y in a group $(G, *)$ such that every element in the group can be written as a product of some number of x's and y's in some order. It is known that

$$x * x = y * y = x * y * x * y = y * x * y * x = e$$

where e is the identity element. The maximum number of elements in such a group is _____.

Q.51　If G is a forest with n vertices and k connected components, how many edges does G have?

(A)　$\lfloor n/k \rfloor$　　　　(B)　$\lceil n/k \rceil$　　　　(C)　$n - k$　　　　(D)　$n - k + 1$

Q.52　Let δ denote the minimum degree of a vertex in a graph. For all planar graphs on n vertices with $\delta \ge 3$, which one of the following is **TRUE**?

(A)　In any planar embedding, the number of faces is at least $\dfrac{n}{2} + 2$

(B)　In any planar embedding, the number of faces is less than $\dfrac{n}{2} + 2$

(C)　There is a planar embedding in which the number of faces is less than $\dfrac{n}{2} + 2$

(D)　There is a planar embedding in which the number of faces is at most $\dfrac{n}{\delta + 1}$

Q.53 The CORRECT formula for the sentence, "not all rainy days are cold" is

(A) $\forall d\ (\text{Rainy}(d) \wedge \sim\text{Cold}(d))$

(B) $\forall d\ (\sim\text{Rainy}(d) \rightarrow \text{Cold}(d))$

(C) $\exists d\ (\sim\text{Rainy}(d) \rightarrow \text{Cold}(d))$

(D) $\exists d\ (\text{Rainy}(d) \wedge \sim\text{Cold}(d))$

Q.54 Consider the following relational schema:

```
employee(empId,empName,empDept)
customer(custId,custName,salesRepId,rating)
```

salesRepId is a foreign key referring to **empId** of the employee relation. Assume that each employee makes a sale to at least one customer. What does the following query return?

```
SELECT empName
FROM employee E
WHERE NOT EXISTS (SELECT custId
                  FROM customer C
                  WHERE C.salesRepId = E.empId
                  AND C.rating <> 'GOOD');
```

(A) Names of all the employees with at least one of their customers having a 'GOOD' rating.

(B) Names of all the employees with at most one of their customers having a 'GOOD' rating.

(C) Names of all the employees with none of their customers having a 'GOOD' rating.

(D) Names of all the employees with all their customers having a 'GOOD' rating.

Q.55 Let $\oplus$ denote the Exclusive OR (XOR) operation. Let '1' and '0' denote the binary constants. Consider the following Boolean expression for F over two variables P and Q:

$$F(P,Q) = \big((1\oplus P)\oplus(P\oplus Q)\big) \oplus \big((P\oplus Q)\oplus(Q\oplus 0)\big)$$

The equivalent expression for F is

(A) $P + Q$ (B) $\overline{P + Q}$ (C) $P \oplus Q$ (D) $\overline{P \oplus Q}$

END OF THE QUESTION PAPER