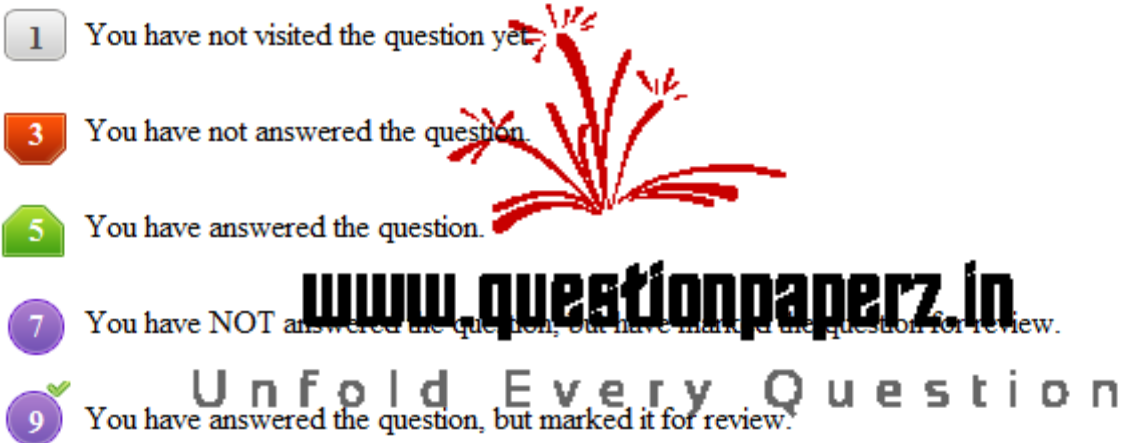


GATE 2014: General Instructions during Examination

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:



The image shows five symbols from the Question Palette, each with a number in a colored circle and a corresponding description. The symbols are: 1 (grey circle), 3 (orange circle), 5 (green circle), 7 (purple circle), and 9 (purple circle with a green checkmark). A red fireworks graphic is positioned behind the symbols. In the background, the text 'www.questionpaperz.in' and 'Unfold Every Question' are visible.

- 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.



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U n f o l d E v e r y Q u e s t i o n

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 of $\frac{1}{3}$ marks for a 1-mark question and $\frac{2}{3}$ 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 Which of the following options is the closest in meaning to the phrase underlined in the sentence below?

It is fascinating to see life forms cope with varied environmental conditions.

- (A) adopt to (B) adapt to (C) adept in (D) accept with

- Q.2 Choose the most appropriate word from the options given below to complete the following sentence.

He could not understand the judges awarding her the first prize, because he thought that her performance was quite _____.

- (A) superb (B) medium (C) mediocre (D) exhilarating

- Q.3 In a press meet on the recent scam, the minister said, "The buck stops here". What did the minister convey by the statement?

- (A) He wants all the money (B) He will return the money
(C) He will assume final responsibility (D) He will resist all enquiries

- Q.4 If $(z + 1/z)^2 = 98$, compute $(z^2 + 1/z^2)$.

- Q.5 The roots of $ax^2 + bx + c = 0$ are real and positive. a , b and c are real. Then $ax^2 + b|x| + c = 0$ has

- (A) no roots (B) 2 real roots
(C) 3 real roots (D) 4 real roots

Q. 6 – Q. 10 carry two marks each.

- Q.6 The Palghat Gap (or Palakkad Gap), a region about 30 km wide in the southern part of the Western Ghats in India, is lower than the hilly terrain to its north and south. The exact reasons for the formation of this gap are not clear. It results in the neighbouring regions of Tamil Nadu getting more rainfall from the South West monsoon and the neighbouring regions of Kerala having higher summer temperatures.

What can be inferred from this passage?

- (A) The Palghat gap is caused by high rainfall and high temperatures in southern Tamil Nadu and Kerala
(B) The regions in Tamil Nadu and Kerala that are near the Palghat Gap are low-lying
(C) The low terrain of the Palghat Gap has a significant impact on weather patterns in neighbouring parts of Tamil Nadu and Kerala
(D) Higher summer temperatures result in higher rainfall near the Palghat Gap area

Q.7 Geneticists say that they are very close to confirming the genetic roots of psychiatric illnesses such as depression and schizophrenia, and consequently, that doctors will be able to eradicate these diseases through early identification and gene therapy.

On which of the following assumptions does the statement above rely?

- (A) Strategies are now available for eliminating psychiatric illnesses
- (B) Certain psychiatric illnesses have a genetic basis
- (C) All human diseases can be traced back to genes and how they are expressed
- (D) In the future, genetics will become the only relevant field for identifying psychiatric illnesses

Q.8 Round-trip tickets to a tourist destination are eligible for a discount of 10% on the total fare. In addition, groups of 4 or more get a discount of 5% on the total fare. If the one way single person fare is Rs 100, a group of 5 tourists purchasing round-trip tickets will be charged Rs _____.

Q.9 In a survey, 300 respondents were asked whether they own a vehicle or not. If yes, they were further asked to mention whether they own a car or scooter or both. Their responses are tabulated below. What percent of respondents do not own a scooter?

		Men	Women
Own vehicle	Car	40	34
	Scooter	30	20
	Both	60	46
Do not own vehicle		20	50

Q.10 When a point inside of a tetrahedron (a solid with four triangular surfaces) is connected by straight lines to its corners, how many (new) internal planes are created with these lines? _____

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 Consider the statement

“Not all that glitters is gold”

Predicate $glitters(x)$ is true if x glitters and predicate $gold(x)$ is true if x is gold. Which one of the following logical formulae represents the above statement?

- (A) $\forall x: glitters(x) \Rightarrow \neg gold(x)$
- (B) $\forall x: gold(x) \Rightarrow glitters(x)$
- (C) $\exists x: gold(x) \wedge \neg glitters(x)$
- (D) $\exists x: glitters(x) \wedge \neg gold(x)$

Q.2 Suppose you break a stick of unit length at a point chosen uniformly at random. Then the expected length of the shorter stick is _____ .

Q.3 Let $G=(V,E)$ be a directed graph where V is the set of vertices and E the set of edges. Then which one of the following graphs has the same strongly connected components as G ?

- (A) $G_1 = (V, E_1)$ where $E_1 = \{(u, v) | (u, v) \notin E\}$
- (B) $G_2 = (V, E_2)$ where $E_2 = \{(u, v) | (v, u) \in E\}$
- (C) $G_3 = (V, E_3)$ where $E_3 = \{(u, v) | \text{there is a path of length } \leq 2 \text{ from } u \text{ to } v \text{ in } E\}$
- (D) $G_4 = (V_4, E)$ where V_4 is the set of vertices in G which are not isolated

Q.4 Consider the following system of equations:

$$\begin{aligned} 3x + 2y &= 1 \\ 4x + 7z &= 1 \\ x + y + z &= 3 \\ x - 2y + 7z &= 0 \end{aligned}$$

The number of solutions for this system is _____

Q.5 The value of the dot product of the eigenvectors corresponding to any pair of different eigenvalues of a 4-by-4 symmetric positive definite matrix is _____.

Q.6 Let the function

$$f(\theta) = \begin{vmatrix} \sin \theta & \cos \theta & \tan \theta \\ \sin(\pi/6) & \cos(\pi/6) & \tan(\pi/6) \\ \sin(\pi/3) & \cos(\pi/3) & \tan(\pi/3) \end{vmatrix}$$

where $\theta \in \left[\frac{\pi}{6}, \frac{\pi}{3}\right]$ and $f'(\theta)$ denote the derivative of f with respect to θ . Which of the following statements is/are **TRUE**?

(I) There exists $\theta \in \left(\frac{\pi}{6}, \frac{\pi}{3}\right)$ such that $f'(\theta) = 0$.

(II) There exists $\theta \in \left(\frac{\pi}{6}, \frac{\pi}{3}\right)$ such that $f'(\theta) \neq 0$.

(A) I only

(B) II only

(C) Both I and II

(D) Neither I nor II

Q.7 Consider the following Boolean expression for F :

$$F(P, Q, R, S) = PQ + \bar{P}QR + \bar{P}Q\bar{R}S$$

The minimal sum-of-products form of F is

(A) $PQ + QR + QS$ (B) $P + Q + R + S$ (C) $\bar{P} + \bar{Q} + \bar{R} + \bar{S}$ (D) $\bar{P}R + \bar{P}\bar{R}S + P$

Q.8 The base (or radix) of the number system such that the following equation holds is _____.

$$\frac{312}{20} = 13.1$$

Q.9 A machine has a 32-bit architecture, with 1-word long instructions. It has 64 registers, each of which is 32 bits long. It needs to support 45 instructions, which have an immediate operand in addition to two register operands. Assuming that the immediate operand is an unsigned integer, the maximum value of the immediate operand is _____.

Q.10 Consider the following program in C language:

```
#include <stdio.h>

main()
{
    int i;
    int *pi = &i;

    scanf("%d", pi);
    printf("%d\n", i+5);
}
```

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

(A) Compilation fails.

(B) Execution results in a run-time error.

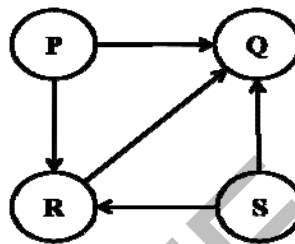
(C) On execution, the value printed is 5 more than the address of variable **i**.

(D) On execution, the value printed is 5 more than the integer value entered.

- Q.11 Let G be a graph with n vertices and m edges. What is the tightest upper bound on the running time of Depth First Search on G , when G is represented as an adjacency matrix?
- (A) $\Theta(n)$ (B) $\Theta(n + m)$ (C) $\Theta(n^2)$ (D) $\Theta(m^2)$

- Q.12 Consider a rooted n node binary tree represented using pointers. The best upper bound on the time required to determine the number of subtrees having exactly 4 nodes is $O(n^a \log^b n)$. Then the value of $a + 10b$ is _____.

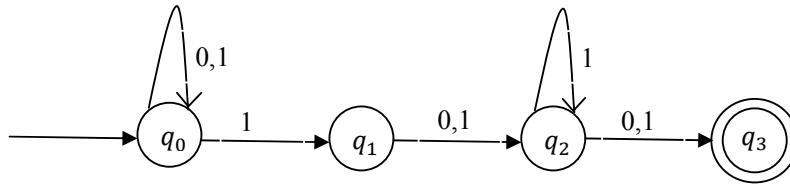
- Q.13 Consider the directed graph given below.



Which one of the following is **TRUE**?

- (A) The graph does not have any topological ordering.
 (B) Both PQRS and SRQP are topological orderings.
 (C) Both PSRQ and SPRQ are topological orderings.
 (D) PSRQ is the only topological ordering.
- Q.14 Let P be a quicksort program to sort numbers in ascending order using the first element as the pivot. Let t_1 and t_2 be the number of comparisons made by P for the inputs [1 2 3 4 5] and [4 1 5 3 2] respectively. Which one of the following holds?
- (A) $t_1 = 5$ (B) $t_1 < t_2$
 (C) $t_1 > t_2$ (D) $t_1 = t_2$
- Q.15 Which one of the following is **TRUE**?
- (A) The language $L = \{a^n b^n \mid n \geq 0\}$ is regular.
 (B) The language $L = \{a^n \mid n \text{ is prime}\}$ is regular.
 (C) The language $L = \{w \mid w \text{ has } 3k + 1 \text{ b's for some } k \in \mathbb{N} \text{ with } \Sigma = \{a, b\}\}$ is regular.
 (D) The language $L = \{ww \mid w \in \Sigma^* \text{ with } \Sigma = \{0,1\}\}$ is regular.

Q.16 Consider the finite automaton in the following figure.



What is the set of reachable states for the input string 0011?

- (A) $\{q_0, q_1, q_2\}$
- (B) $\{q_0, q_1\}$
- (C) $\{q_0, q_1, q_2, q_3\}$
- (D) $\{q_3\}$

Q.17 Which one of the following is **FALSE**?

- (A) A basic block is a sequence of instructions where control enters the sequence at the beginning and exits at the end.
- (B) Available expression analysis can be used for common subexpression elimination.
- (C) Live variable analysis can be used for dead code elimination.
- (D) $x = 4 * 5 \Rightarrow x = 20$ is an example of common subexpression elimination.

Q.18 Match the following:

- | | |
|---|---|
| 1) Waterfall model | a) Specifications can be developed incrementally |
| 2) Evolutionary model | b) Requirements compromises are inevitable |
| 3) Component-based software engineering | c) Explicit recognition of risk |
| 4) Spiral development | d) Inflexible partitioning of the project into stages |
-
- (A) 1-a, 2-b, 3-c, 4-d
 - (B) 1-d, 2-a, 3-b, 4-c
 - (C) 1-d, 2-b, 3-a, 4-c
 - (D) 1-c, 2-a, 3-b, 4-d

Q.19 Suppose a disk has 201 cylinders, numbered from 0 to 200. At some time the disk arm is at cylinder 100, and there is a queue of disk access requests for cylinders 30, 85, 90, 100, 105, 110, 135 and 145. If Shortest-Seek Time First (SSTF) is being used for scheduling the disk access, the request for cylinder 90 is serviced after servicing _____ number of requests.

Q.20 Which one of the following is **FALSE**?

- (A) User level threads are not scheduled by the kernel.
- (B) When a user level thread is blocked, all other threads of its process are blocked.
- (C) Context switching between user level threads is faster than context switching between kernel level threads.
- (D) Kernel level threads cannot share the code segment.

Q.21 Consider the relation scheme $R = (E, F, G, H, I, J, K, L, M, N)$ and the set of functional dependencies $\{\{E, F\} \rightarrow \{G\}, \{F\} \rightarrow \{I, J\}, \{E, H\} \rightarrow \{K, L\}, \{K\} \rightarrow \{M\}, \{L\} \rightarrow \{N\}\}$ on R . What is the key for R ?

- (A) $\{E, F\}$ (B) $\{E, F, H\}$ (C) $\{E, F, H, K, L\}$ (D) $\{E\}$

Q.22 Given the following statements:

S1: A foreign key declaration can always be replaced by an equivalent check assertion in SQL.

S2: Given the table $R(a, b, c)$ where a and b together form the primary key, the following is a valid table definition.

```
CREATE TABLE S (  
    a INTEGER,  
    d INTEGER,  
    e INTEGER,  
    PRIMARY KEY (d),  
    FOREIGN KEY (a) references R)
```

Which one of the following statements is **CORRECT**?

- (A) S1 is TRUE and S2 is FALSE.
- (B) Both S1 and S2 are TRUE.
- (C) S1 is FALSE and S2 is TRUE.
- (D) Both S1 and S2 are FALSE.

Q.23 Consider the following three statements about link state and distance vector routing protocols, for a large network with 500 network nodes and 4000 links.

[S1] The computational overhead in link state protocols is higher than in distance vector protocols.

[S2] A distance vector protocol (with split horizon) avoids persistent routing loops, but not a link state protocol.

[S3] After a topology change, a link state protocol will converge faster than a distance vector protocol.

Which one of the following is correct about S1, S2, and S3 ?

(A) S1, S2, and S3 are all true.

(B) S1, S2, and S3 are all false.

(C) S1 and S2 are true, but S3 is false.

(D) S1 and S3 are true, but S2 is false.

Q.24 Which of the following are used to generate a message digest by the network security protocols?

(P) RSA

(Q) SHA-1

(R) DES

(S) MD5

(A) P and R only

(B) Q and R only

(C) Q and S only

(D) R and S only

Q.25 Identify the correct order in which the following actions take place in an interaction between a web browser and a web server.

1. The web browser requests a webpage using HTTP.
2. The web browser establishes a TCP connection with the web server.
3. The web server sends the requested webpage using HTTP.
4. The web browser resolves the domain name using DNS.

(A) 4,2,1,3

(B) 1,2,3,4

(C) 4,1,2,3

(D) 2,4,1,3

Q. 26 – Q. 55 carry two marks each.

Q.26 Consider a token ring network with a length of 2 km having 10 stations including a monitoring station. The propagation speed of the signal is 2×10^8 m/s and the token transmission time is ignored. If each station is allowed to hold the token for 2 μ sec, the minimum time for which the monitoring station should wait (**in μ sec**) before assuming that the token is lost is _____.

Q.27 Let the size of congestion window of a TCP connection be 32 KB when a timeout occurs. The round trip time of the connection is 100 msec and the maximum segment size used is 2 KB. The time taken (**in msec**) by the TCP connection to get back to 32 KB congestion window is _____.

Q.28 Consider a selective repeat sliding window protocol that uses a frame size of 1 KB to send data on a 1.5 Mbps link with a one-way latency of 50 msec. To achieve a link utilization of 60%, the minimum number of bits required to represent the sequence number field is _____.

Q.29 Consider the following four schedules due to three transactions (indicated by the subscript) using *read* and *write* on a data item x , denoted by $r(x)$ and $w(x)$ respectively. Which one of them is conflict serializable?

- (A) $r_1(x); r_2(x); w_1(x); r_3(x); w_2(x)$
- (B) $r_2(x); r_1(x); w_2(x); r_3(x); w_1(x)$
- (C) $r_3(x); r_2(x); r_1(x); w_2(x); w_1(x)$
- (D) $r_2(x); w_2(x); r_3(x); r_1(x); w_1(x)$

Q.30 Given the following two statements:

S1: Every table with two single-valued attributes is in 1NF, 2NF, 3NF and BCNF.

S2: $AB \rightarrow C, D \rightarrow E, E \rightarrow C$ is a minimal cover for the set of functional dependencies $AB \rightarrow C, D \rightarrow E, AB \rightarrow E, E \rightarrow C$.

Which one of the following is **CORRECT**?

- (A) S1 is TRUE and S2 is FALSE.
- (B) Both S1 and S2 are TRUE.
- (C) S1 is FALSE and S2 is TRUE.
- (D) Both S1 and S2 are FALSE.

- Q.31 An operating system uses the *Banker's algorithm* for deadlock avoidance when managing the allocation of three resource types X, Y, and Z to three processes P0, P1, and P2. The table given below presents the current system state. Here, the *Allocation* matrix shows the current number of resources of each type allocated to each process and the *Max* matrix shows the maximum number of resources of each type required by each process during its execution.

	Allocation			Max		
	X	Y	Z	X	Y	Z
P0	0	0	1	8	4	3
P1	3	2	0	6	2	0
P2	2	1	1	3	3	3

There are 3 units of type X, 2 units of type Y and 2 units of type Z still available. The system is currently in a **safe** state. Consider the following independent requests for additional resources in the current state:

REQ1: P0 requests 0 units of X, 0 units of Y and 2 units of Z
 REQ2: P1 requests 2 units of X, 0 units of Y and 0 units of Z

Which one of the following is **TRUE**?

- (A) Only REQ1 can be permitted.
 (B) Only REQ2 can be permitted.
 (C) Both REQ1 and REQ2 can be permitted.
 (D) Neither REQ1 nor REQ2 can be permitted.
- Q.32 Consider the following set of processes that need to be scheduled on a single CPU. All the times are given in milliseconds.

Process Name	Arrival Time	Execution Time
A	0	6
B	3	2
C	5	4
D	7	6
E	10	3

Using the *shortest remaining time first* scheduling algorithm, the average process turnaround time (in msec) is _____.

- Q.33 Assume that there are 3 page frames which are initially empty. If the page reference string is 1, 2, 3, 4, 2, 1, 5, 3, 2, 4, 6, the number of page faults using the *optimal replacement policy* is _____.

- Q.34 A canonical set of items is given below

$$S \rightarrow L . > R$$

$$Q \rightarrow R .$$

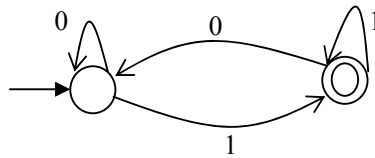
On input symbol < the set has

- (A) a shift-reduce conflict and a reduce-reduce conflict.
 (B) a shift-reduce conflict but not a reduce-reduce conflict.
 (C) a reduce-reduce conflict but not a shift-reduce conflict.
 (D) neither a shift-reduce nor a reduce-reduce conflict.

Q.35 Let L be a language and \bar{L} be its complement. Which one of the following is NOT a viable possibility?

- (A) Neither L nor \bar{L} is recursively enumerable (r.e.).
- (B) One of L and \bar{L} is r.e. but not recursive; the other is not r.e.
- (C) Both L and \bar{L} are r.e. but not recursive.
- (D) Both L and \bar{L} are recursive.

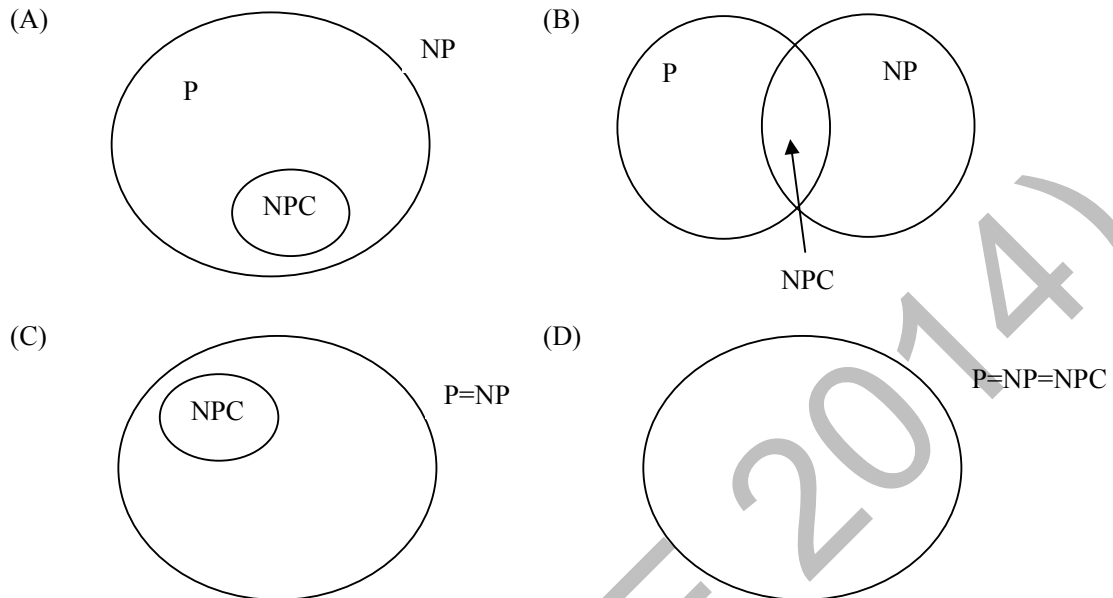
Q.36 Which of the regular expressions given below represent the following DFA?



- I) $0^*1(1+00^*1)^*$
 - II) $0^*1^*1+11^*0^*1$
 - III) $(0+1)^*1$
- (A) I and II only
 - (B) I and III only
 - (C) II and III only
 - (D) I, II, and III

Q.37 There are 5 bags labeled 1 to 5. All the coins in a given bag have the same weight. Some bags have coins of weight 10 gm, others have coins of weight 11 gm. I pick 1, 2, 4, 8, 16 coins respectively from bags 1 to 5. Their total weight comes out to 323 gm. Then the product of the labels of the bags having 11 gm coins is ____.

Q.38 Suppose a polynomial time algorithm is discovered that correctly computes the largest clique in a given graph. In this scenario, which one of the following represents the correct Venn diagram of the complexity classes P, NP and NP Complete (NPC)?



Q.39 The minimum number of comparisons required to find the minimum and the maximum of 100 numbers is _____.

Q.40 Consider a hash table with 9 slots. The hash function is $h(k) = k \bmod 9$. The collisions are resolved by chaining. The following 9 keys are inserted in the order: 5, 28, 19, 15, 20, 33, 12, 17, 10. The maximum, minimum, and average chain lengths in the hash table, respectively, are

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

Q.41 Consider the following C function in which **size** is the number of elements in the array **E**:

```
int MyX(int *E, unsigned int size)
{
    int Y = 0;
    int Z;
    int i, j, k;

    for(i = 0; i < size; i++)
        Y = Y + E[i];

    for(i = 0; i < size; i++)
        for(j = i; j < size; j++)
        {
            Z = 0;
            for(k = i; k <= j; k++)
                Z = Z + E[k];
            if (Z > Y)
                Y = Z;
        }
    return Y;
}
```

The value returned by the function **MyX** is the

- (A) maximum possible sum of elements in any sub-array of array **E**.
- (B) maximum element in any sub-array of array **E**.
- (C) sum of the maximum elements in all possible sub-arrays of array **E**.
- (D) the sum of all the elements in the array **E**.

Q.42 Consider the following pseudo code. What is the total number of multiplications to be performed?

```
D = 2
for i = 1 to n do
    for j = i to n do
        for k = j + 1 to n do
            D = D * 3
```

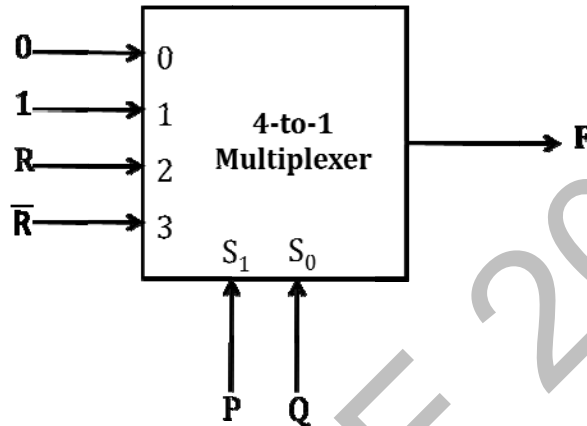
- (A) Half of the product of the 3 consecutive integers.
- (B) One-third of the product of the 3 consecutive integers.
- (C) One-sixth of the product of the 3 consecutive integers.
- (D) None of the above.

Q.43 Consider a 6-stage instruction pipeline, where all stages are perfectly balanced. Assume that there is no cycle-time overhead of pipelining. When an application is executing on this 6-stage pipeline, the speedup achieved with respect to non-pipelined execution if 25% of the instructions incur 2 pipeline stall cycles is _____.

Q.44 An access sequence of cache block addresses is of length N and contains n unique block addresses. The number of unique block addresses between two consecutive accesses to the same block address is bounded above by k . What is the miss ratio if the access sequence is passed through a cache of associativity $A \geq k$ exercising least-recently-used replacement policy?

- (A) n/N (B) $1/N$ (C) $1/A$ (D) k/n

Q.45 Consider the 4-to-1 multiplexer with two select lines S_1 and S_0 given below.



The minimal sum-of-products form of the Boolean expression for the output F of the multiplexer is

- (A) $\bar{P}Q + Q\bar{R} + P\bar{Q}R$
 (B) $\bar{P}Q + \bar{P}Q\bar{R} + PQ\bar{R} + P\bar{Q}R$
 (C) $\bar{P}QR + \bar{P}Q\bar{R} + Q\bar{R} + P\bar{Q}R$
 (D) $PQ\bar{R}$

Q.46 The function $f(x) = x \sin x$ satisfies the following equation: $f''(x) + f(x) + t \cos x = 0$. The value of t is _____.

Q.47 A function $f(x)$ is continuous in the interval $[0,2]$. It is known that $f(0) = f(2) = -1$ and $f(1) = 1$. Which one of the following statements must be true?

- (A) There exists a y in the interval $(0,1)$ such that $f(y) = f(y + 1)$
 (B) For every y in the interval $(0,1)$, $f(y) = f(2 - y)$
 (C) The maximum value of the function in the interval $(0,2)$ is 1
 (D) There exists a y in the interval $(0,1)$ such that $f(y) = -f(2 - y)$

Q.48 Four fair six-sided dice are rolled. The probability that the sum of the results being 22 is $X/1296$. The value of X is _____.

- Q.49 A pennant is a sequence of numbers, each number being 1 or 2. An n -pennant is a sequence of numbers with sum equal to n . For example, $(1,1,2)$ is a 4-pennant. The set of all possible 1-pennants is $\{(1)\}$, the set of all possible 2-pennants is $\{(2), (1,1)\}$ and the set of all 3-pennants is $\{(2,1), (1,1,1), (1,2)\}$. Note that the pennant $(1,2)$ is not the same as the pennant $(2,1)$. The number of 10-pennants is _____.
- Q.50 Let S denote the set of all functions $f: \{0,1\}^4 \rightarrow \{0,1\}$. Denote by N the number of functions from S to the set $\{0,1\}$. The value of $\log_2 \log_2 N$ is _____.
- Q.51 Consider an undirected graph G where self-loops are not allowed. The vertex set of G is $\{(i,j): 1 \leq i \leq 12, 1 \leq j \leq 12\}$. There is an edge between (a,b) and (c,d) if $|a - c| \leq 1$ and $|b - d| \leq 1$. The number of edges in this graph is _____.
- Q.52 An ordered n -tuple (d_1, d_2, \dots, d_n) with $d_1 \geq d_2 \geq \dots \geq d_n$ is called *graphic* if there exists a simple undirected graph with n vertices having degrees d_1, d_2, \dots, d_n respectively. Which of the following 6-tuples is NOT graphic?
- (A) $(1, 1, 1, 1, 1, 1)$ (B) $(2, 2, 2, 2, 2, 2)$
(C) $(3, 3, 3, 1, 0, 0)$ (D) $(3, 2, 1, 1, 1, 0)$
- Q.53 Which one of the following propositional logic formulas is TRUE when exactly two of p , q , and r are **TRUE**?
- (A) $((p \leftrightarrow q) \wedge r) \vee (p \wedge q \wedge \sim r)$
(B) $(\sim (p \leftrightarrow q) \wedge r) \vee (p \wedge q \wedge \sim r)$
(C) $((p \rightarrow q) \wedge r) \vee (p \wedge q \wedge \sim r)$
(D) $(\sim (p \leftrightarrow q) \wedge r) \wedge (p \wedge q \wedge \sim r)$

Q.54 Given the following schema:

```
employees(emp-id, first-name, last-name, hire-date,  
          dept-id, salary)  
departments(dept-id, dept-name, manager-id, location-id)
```

You want to display the last names and hire dates of all latest hires in their respective departments in the location ID 1700. You issue the following query:

```
SQL>SELECT last-name, hire-date  
       FROM employees  
       WHERE (dept-id, hire-date) IN  
             (SELECT dept-id, MAX(hire-date)  
              FROM employees JOIN departments USING(dept-id)  
              WHERE location-id = 1700  
              GROUP BY dept-id);
```

What is the outcome?


- (A) It executes but does not give the correct result.
- (B) It executes and gives the correct result.
- (C) It generates an error because of pairwise comparison.
- (D) It generates an error because the GROUP BY clause cannot be used with table joins in a sub-query.


Q.55 Consider two processors P_1 and P_2 executing the same instruction set. Assume that under identical conditions, for the same input, a program running on P_2 takes 25% less time but incurs 20% more CPI (clock cycles per instruction) as compared to the program running on P_1 . If the clock frequency of P_1 is 1GHz, then the clock frequency of P_2 (in GHz) is _____.


END OF THE QUESTION PAPER


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:

 You have not visited the question yet.

 You have not answered the question.

 You have answered the question.

 You have NOT answered the question, but have marked the question for review.

 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 of $\frac{1}{3}$ marks for a 1-mark question and $\frac{2}{3}$ 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 Choose the most appropriate phrase from the options given below to complete the following sentence.

India is a post-colonial country because

- (A) it was a former British colony
- (B) Indian Information Technology professionals have colonized the world
- (C) India does not follow any colonial practices
- (D) India has helped other countries gain freedom

- Q.2 Who _____ was coming to see us this evening?

- (A) you said
- (B) did you say
- (C) did you say that
- (D) had you said

- Q.3 Match the columns.

Column 1

- 1) eradicate
- 2) distort
- 3) saturate
- 4) utilize

Column 2

- P) misrepresent
- Q) soak completely
- R) use
- S) destroy utterly

- (A) 1:S, 2:P, 3:Q, 4:R
- (C) 1:Q, 2:R, 3:S, 4:P

- (B) 1:P, 2:Q, 3:R, 4:S
- (D) 1:S, 2:P, 3:R, 4:Q

- Q.4 What is the average of all multiples of 10 from 2 to 198?

- (A) 90
- (B) 100
- (C) 110
- (D) 120

- Q.5 The value of $\sqrt{12 + \sqrt{12 + \sqrt{12 + \dots}}}$ is

- (A) 3.464
- (B) 3.932
- (C) 4.000
- (D) 4.444

Q. 6 – Q. 10 carry two marks each.

- Q.6 The old city of Koenigsberg, which had a German majority population before World War 2, is now called Kaliningrad. After the events of the war, Kaliningrad is now a Russian territory and has a predominantly Russian population. It is bordered by the Baltic Sea on the north and the countries of Poland to the south and west and Lithuania to the east respectively. Which of the statements below can be inferred from this passage?

- (A) Kaliningrad was historically Russian in its ethnic make up
- (B) Kaliningrad is a part of Russia despite it not being contiguous with the rest of Russia
- (C) Koenigsberg was renamed Kaliningrad, as that was its original Russian name
- (D) Poland and Lithuania are on the route from Kaliningrad to the rest of Russia

Q.7 The number of people diagnosed with dengue fever (contracted from the bite of a mosquito) in north India is twice the number diagnosed last year. Municipal authorities have concluded that measures to control the mosquito population have failed in this region.

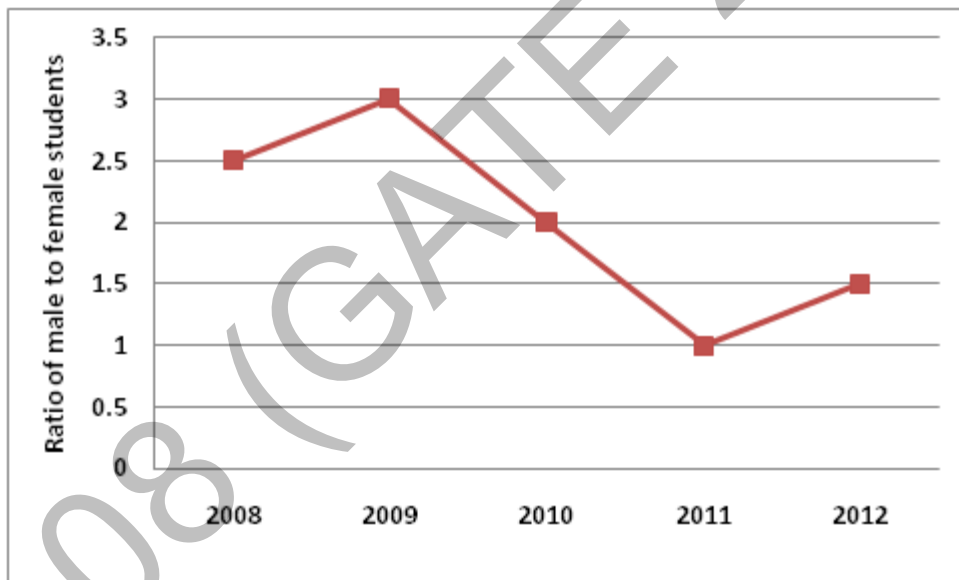
Which one of the following statements, if true, does not contradict this conclusion?

- (A) A high proportion of the affected population has returned from neighbouring countries where dengue is prevalent
- (B) More cases of dengue are now reported because of an increase in the Municipal Office's administrative efficiency
- (C) Many more cases of dengue are being diagnosed this year since the introduction of a new and effective diagnostic test
- (D) The number of people with malarial fever (also contracted from mosquito bites) has increased this year

Q.8 If x is real and $|x^2 - 2x + 3| = 11$, then possible values of $|-x^3 + x^2 - x|$ include

- (A) 2, 4 (B) 2, 14 (C) 4, 52 (D) 14, 52

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 doubled in 2009, by what percent did the number of male students increase in 2009?



Q.10 At what time between 6 a.m. and 7 a.m. will the minute hand and hour hand of a clock make an angle closest to 60° ?

- (A) 6: 22 a.m. (B) 6: 27 a.m.
(C) 6: 38 a.m. (D) 6: 45 a.m.

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 The security system at an IT office is composed of 10 computers of which exactly four are working. To check whether the system is functional, the officials inspect four of the computers picked at random (without replacement). The system is deemed functional if at least three of the four computers inspected are working. Let the probability that the system is deemed functional be denoted by p . Then $100p =$ _____.

Q.2 Each of the nine words in the sentence "**The quick brown fox jumps over the lazy dog**" is written on a separate piece of paper. These nine pieces of paper are kept in a box. One of the pieces is drawn at random from the box. The *expected* length of the word drawn is _____. (The answer should be rounded to one decimal place.)

Q.3 The maximum number of edges in a bipartite graph on 12 vertices is _____.

Q.4 If the matrix A is such that

$$A = \begin{bmatrix} 2 \\ -4 \\ 7 \end{bmatrix} [1 \ 9 \ 5]$$

then the determinant of A is equal to _____.

Q.5 A non-zero polynomial $f(x)$ of degree 3 has roots at $x = 1, x = 2$ and $x = 3$. Which one of the following must be TRUE?

- (A) $f(0)f(4) < 0$
- (B) $f(0)f(4) > 0$
- (C) $f(0) + f(4) > 0$
- (D) $f(0) + f(4) < 0$

Q.6 The dual of a Boolean function $F(x_1, x_2, \dots, x_n, +, \cdot, ')$, written as F^D , is the same expression as that of F with $+$ and \cdot swapped. F is said to be self-dual if $F = F^D$. The number of self-dual functions with n Boolean variables is

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

Q.7 Let $k = 2^n$. A circuit is built by giving the output of an n -bit binary counter as input to an n -to- 2^n bit decoder. This circuit is equivalent to a

- (A) k -bit binary up counter.
- (B) k -bit binary down counter.
- (C) k -bit ring counter.
- (D) k -bit Johnson counter.

Q.8 Consider the equation $(123)_5 = (x8)_y$ with x and y as unknown. The number of possible solutions is _____.

Q.9 A 4-way set-associative cache memory unit with a capacity of 16 KB is built using a block size of 8 words. The word length is 32 bits. The size of the physical address space is 4 GB. The number of bits for the TAG field is _____

Q.10 Consider the function `func` shown below:

```
int func(int num) {
    int count = 0;
    while (num) {
        count++;
        num >>= 1;
    }
    return (count);
}
```

The value returned by `func(435)` is _____.

Q.11 Suppose n and p are unsigned `int` variables in a C program. We wish to set p to ${}^n C_3$. If n is large, which one of the following statements is most likely to set p correctly?

- (A) $p = n * (n-1) * (n-2) / 6;$
- (B) $p = n * (n-1) / 2 * (n-2) / 3;$
- (C) $p = n * (n-1) / 3 * (n-2) / 2;$
- (D) $p = n * (n-1) * (n-2) / 6.0;$

- Q.12 A priority queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is: 10, 8, 5, 3, 2. Two new elements 1 and 7 are inserted into the heap in that order. The level-order traversal of the heap after the insertion of the elements is:
- (A) 10, 8, 7, 3, 2, 1, 5 (B) 10, 8, 7, 2, 3, 1, 5
(C) 10, 8, 7, 1, 2, 3, 5 (D) 10, 8, 7, 5, 3, 2, 1

- Q.13 Which one of the following correctly determines the solution of the recurrence relation with $T(1) = 1$?

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

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

- Q.14 Consider the tree arcs of a BFS traversal from a source node \mathbf{W} in an unweighted, connected, undirected graph. The tree \mathbf{T} formed by the tree arcs is a data structure for computing

- (A) the shortest path between every pair of vertices.
(B) the shortest path from \mathbf{W} to every vertex in the graph.
(C) the shortest paths from \mathbf{W} to only those nodes that are leaves of \mathbf{T} .
(D) the longest path in the graph.

- Q.15 If $L_1 = \{a^n \mid n \geq 0\}$ and $L_2 = \{b^n \mid n \geq 0\}$, consider

- (I) $L_1 \cdot L_2$ is a regular language
(II) $L_1 \cdot L_2 = \{a^n b^n \mid n \geq 0\}$

Which one of the following is CORRECT?

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

- Q.16 Let $A \leq_m B$ denotes that language A is mapping reducible (also known as many-to-one reducible) to language B. Which one of the following is FALSE?

- (A) If $A \leq_m B$ and B is recursive then A is recursive.
(B) If $A \leq_m B$ and A is undecidable then B is undecidable.
(C) If $A \leq_m B$ and B is recursively enumerable then A is recursively enumerable.
(D) If $A \leq_m B$ and B is not recursively enumerable then A is not recursively enumerable.

Q.17 Consider the grammar defined by the following production rules, with two operators * and +

$$\begin{aligned}S &\rightarrow T * P \\T &\rightarrow U \mid T * U \\P &\rightarrow Q + P \mid Q \\Q &\rightarrow Id \\U &\rightarrow Id\end{aligned}$$

Which one of the following is TRUE?

- (A) + is left associative, while * is right associative
- (B) + is right associative, while * is left associative
- (C) Both + and * are right associative
- (D) Both + and * are left associative

Q.18 Which one of the following is **NOT** performed during compilation?

- (A) Dynamic memory allocation
- (B) Type checking
- (C) Symbol table management
- (D) Inline expansion

Q.19 Which one of the following is TRUE?

- (A) The requirements document also describes how the requirements that are listed in the document are implemented efficiently.
- (B) Consistency and completeness of functional requirements are always achieved in practice.
- (C) Prototyping is a method of requirements validation.
- (D) Requirements review is carried out to find the errors in system design.

Q.20 A FAT (file allocation table) based file system is being used and the total overhead of each entry in the FAT is 4 bytes in size. Given a 100×10^6 bytes disk on which the file system is stored and data block size is 10^3 bytes, the maximum size of a file that can be stored on this disk in units of 10^6 bytes is _____.

Q.21 The maximum number of superkeys for the relation schema $R(E, F, G, H)$ with E as the key is _____.

Q.22 Given an instance of the STUDENTS relation as shown below:

<i>StudentID</i>	<i>StudentName</i>	<i>StudentEmail</i>	<i>StudentAge</i>	<i>CPI</i>
2345	Shankar	shankar@math	X	9.4
1287	Swati	swati@ee	19	9.5
7853	Shankar	shankar@cse	19	9.4
9876	Swati	swati@mech	18	9.3
8765	Ganesh	ganesh@civil	19	8.7

For (*StudentName*, *StudentAge*) to be a key for this instance, the value X should NOT be equal to _____.

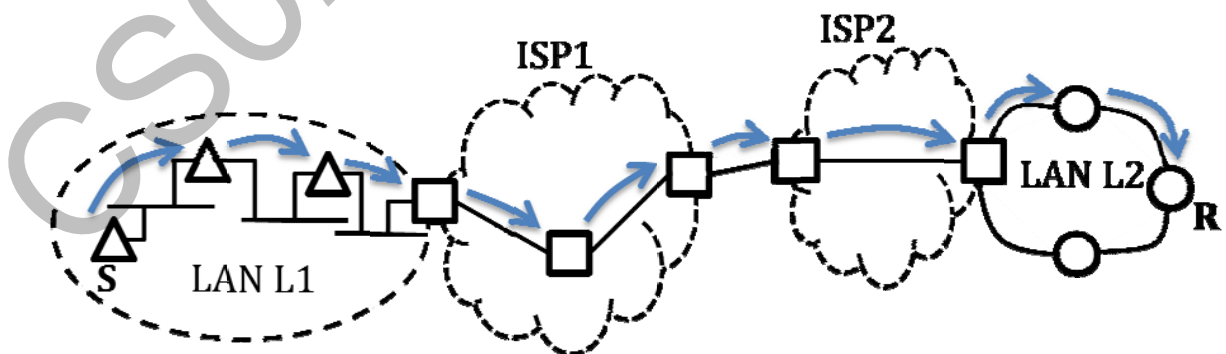
Q.23 Which one of the following is TRUE about the interior gateway routing protocols – Routing Information Protocol (RIP) and Open Shortest Path First (OSPF)?

- (A) RIP uses distance vector routing and OSPF uses link state routing
- (B) OSPF uses distance vector routing and RIP uses link state routing
- (C) Both RIP and OSPF use link state routing
- (D) Both RIP and OSPF use distance vector routing

Q.24 Which one of the following socket API functions converts an unconnected active TCP socket into a passive socket?

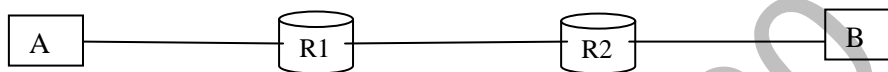
- (A) connect
- (B) bind
- (C) listen
- (D) accept

Q.25 In the diagram shown below, L1 is an Ethernet LAN and L2 is a Token-Ring LAN. An IP packet originates from sender S and traverses to R, as shown. The links within each ISP and across the two ISPs, are all point-to-point optical links. The initial value of the TTL field is 32. The maximum possible value of the TTL field when R receives the datagram is _____.



Q. 26 – Q. 55 carry two marks each.

- Q.26 Consider the store and forward packet switched network given below. Assume that the bandwidth of each link is 10^6 bytes / sec. A user on host A sends a file of size 10^3 bytes to host B through routers R1 and R2 in three different ways. In the first case a single packet containing the complete file is transmitted from A to B. In the second case, the file is split into 10 equal parts, and these packets are transmitted from A to B. In the third case, the file is split into 20 equal parts and these packets are sent from A to B. Each packet contains 100 bytes of header information along with the user data. Consider only transmission time and ignore processing, queuing and propagation delays. Also assume that there are no errors during transmission. Let T_1 , T_2 and T_3 be the times taken to transmit the file in the first, second and third case respectively. Which one of the following is CORRECT?



- (A) $T_1 < T_2 < T_3$
 (B) $T_1 > T_2 > T_3$
 (C) $T_2 = T_3, T_3 < T_1$
 (D) $T_1 = T_3, T_3 > T_2$

- Q.27 An IP machine Q has a path to another IP machine H via three IP routers R1, R2, and R3.

Q—R1—R2—R3—H

H acts as an HTTP server, and Q connects to H via HTTP and downloads a file. Session layer encryption is used, with DES as the shared key encryption protocol. Consider the following four pieces of information:

- [I1] The URL of the file downloaded by Q
 [I2] The TCP port numbers at Q and H
 [I3] The IP addresses of Q and H
 [I4] The link layer addresses of Q and H

Which of I1, I2, I3, and I4 can an intruder learn through sniffing at R2 alone?

- (A) Only I1 and I2
 (B) Only I1
 (C) Only I2 and I3
 (D) Only I3 and I4

Q.28 A graphical HTML browser resident at a network client machine Q accesses a static HTML webpage from a HTTP server S . The static HTML page has exactly one static embedded image which is also at S . Assuming no caching, which one of the following is correct about the HTML webpage loading (including the embedded image)?

- (A) Q needs to send at least 2 HTTP requests to S , each necessarily in a separate TCP connection to server S
- (B) Q needs to send at least 2 HTTP requests to S , but a single TCP connection to server S is sufficient
- (C) A single HTTP request from Q to S is sufficient, and a single TCP connection between Q and S is necessary for this
- (D) A single HTTP request from Q to S is sufficient, and this is possible without any TCP connection between Q and S

Q.29 Consider the following schedule S of transactions T1, T2, T3, T4:

T1	T2	T3	T4
Writes(X) Commit	Reads(X) Writes(Y) Reads(Z) Commit	Writes(X) Commit	Reads(X) Reads(Y) Commit

Which one of the following statements is CORRECT?

- (A) S is conflict-serializable but not recoverable
- (B) S is not conflict-serializable but is recoverable
- (C) S is both conflict-serializable and recoverable
- (D) S is neither conflict-serializable nor is it recoverable

- Q.30 Consider a join (relation algebra) between relations $r(R)$ and $s(S)$ using the nested loop method. There are 3 buffers each of size equal to disk block size, out of which one buffer is reserved for intermediate results. Assuming $\text{size}(r(R)) < \text{size}(s(S))$, the join will have fewer number of disk block accesses if
- (A) relation $r(R)$ is in the outer loop.
 - (B) relation $s(S)$ is in the outer loop.
 - (C) join selection factor between $r(R)$ and $s(S)$ is more than 0.5.
 - (D) join selection factor between $r(R)$ and $s(S)$ is less than 0.5.

- Q.31 Consider the procedure below for the *Producer-Consumer* problem which uses semaphores:

```
semaphore n = 0;
semaphore s = 1;
void producer()
{
    while(true)
    {
        produce();
        semWait(s);
        addToBuffer();
        semSignal(s);
        semSignal(n);
    }
}

void consumer()
{
    while(true)
    {
        semWait(s);
        semWait(n);
        removeFromBuffer();
        semSignal(s);
        consume();
    }
}
```

Which one of the following is **TRUE**?

- (A) The producer will be able to add an item to the buffer, but the consumer can never consume it.
- (B) The consumer will remove no more than one item from the buffer.
- (C) Deadlock occurs if the consumer succeeds in acquiring semaphore s when the buffer is empty.
- (D) The starting value for the semaphore n must be 1 and not 0 for deadlock-free operation.

- Q.32 Three processes A, B and C each execute a loop of 100 iterations. In each iteration of the loop, a process performs a single computation that requires t_c CPU milliseconds and then initiates a single I/O operation that lasts for t_{io} milliseconds. It is assumed that the computer where the processes execute has sufficient number of I/O devices and the OS of the computer assigns different I/O devices to each process. Also, the scheduling overhead of the OS is negligible. The processes have the following characteristics:

Process id	t_c	t_{io}
A	100 ms	500 ms
B	350 ms	500 ms
C	200 ms	500 ms

The processes A, B, and C are started at times 0, 5 and 10 milliseconds respectively, in a pure time sharing system (round robin scheduling) that uses a time slice of 50 milliseconds. The time in milliseconds at which process C would *complete* its first I/O operation is _____.

- Q.33 A computer has twenty physical page frames which contain pages numbered 101 through 120. Now a program accesses the pages numbered 1, 2, ..., 100 in that order, and repeats the access sequence THRICE. Which one of the following page replacement policies experiences the same number of page faults as the optimal page replacement policy for this program?

- (A) Least-recently-used
 (B) First-in-first-out
 (C) Last-in-first-out
 (D) Most-recently-used

- Q.34 For a C program accessing $x[i][j][k]$, the following intermediate code is generated by a compiler. Assume that the size of an **integer** is 32 bits and the size of a **character** is 8 bits.

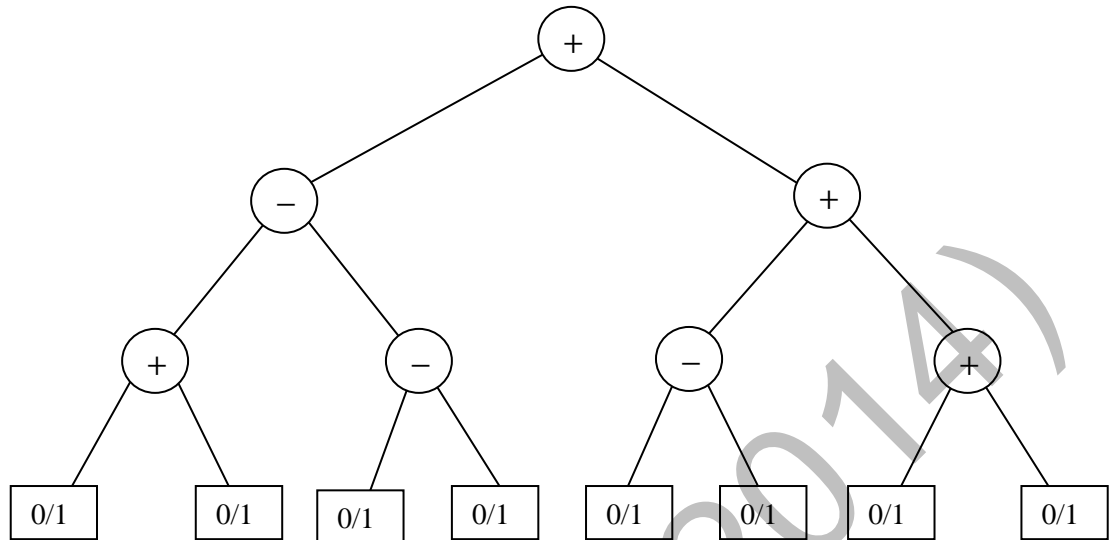
```
t0 = i * 1024
t1 = j * 32
t2 = k * 4
t3 = t1 + t0
t4 = t3 + t2
t5 = x[t4]
```

Which one of the following statements about the source code for the C program is **CORRECT**?

- (A) **x** is declared as “**int x[32][32][8]**”.
 (B) **x** is declared as “**int x[4][1024][32]**”.
 (C) **x** is declared as “**char x[4][32][8]**”.
 (D) **x** is declared as “**char x[32][16][2]**”.

- Q.35 Let $\langle M \rangle$ be the encoding of a Turing machine as a string over $\Sigma = \{0, 1\}$. Let $L = \{\langle M \rangle \mid M \text{ is a Turing machine that accepts a string of length } 2014\}$. Then, L is
- (A) decidable and recursively enumerable
 - (B) undecidable but recursively enumerable
 - (C) undecidable and not recursively enumerable
 - (D) decidable but not recursively enumerable
- Q.36 Let $L_1 = \{w \in \{0,1\}^* \mid w \text{ has at least as many occurrences of } (110)\text{'s as } (011)\text{'s}\}$. Let $L_2 = \{w \in \{0,1\}^* \mid w \text{ has at least as many occurrences of } (000)\text{'s as } (111)\text{'s}\}$. Which one of the following is TRUE?
- (A) L_1 is regular but not L_2
 - (B) L_2 is regular but not L_1
 - (C) Both L_1 and L_2 are regular
 - (D) Neither L_1 nor L_2 are regular
- Q.37 Consider two strings $A = "qpqrr"$ and $B = "pqprrqp"$. Let x be the length of the longest common subsequence (not necessarily contiguous) between A and B and let y be the number of such longest common subsequences between A and B . Then $x + 10y = \underline{\hspace{2cm}}$.
- Q.38 Suppose P, Q, R, S, T are sorted sequences having lengths 20, 24, 30, 35, 50 respectively. They are to be merged into a single sequence by merging together two sequences at a time. The number of comparisons that will be needed in the worst case by the optimal algorithm for doing this is $\underline{\hspace{2cm}}$.

- Q.39 Consider the expression tree shown. Each leaf represents a numerical value, which can either be 0 or 1. Over all possible choices of the values at the leaves, the maximum possible value of the expression represented by the tree is ____.



- Q.40 Consider the following function

```
double f(double x) {
    if( abs(x*x - 3) < 0.01) return x;
    else return f(x/2 + 1.5/x);
}
```

Give a value q (to 2 decimals) such that $f(q)$ will return q :_____.

- Q.41 Suppose a stack implementation supports an instruction REVERSE, which reverses the order of elements on the stack, in addition to the PUSH and POP instructions. Which one of the following statements is TRUE with respect to this modified stack?
- (A) A queue cannot be implemented using this stack.
- (B) A queue can be implemented where ENQUEUE takes a single instruction and DEQUEUE takes a sequence of two instructions.
- (C) A queue can be implemented where ENQUEUE takes a sequence of three instructions and DEQUEUE takes a single instruction.
- (D) A queue can be implemented where both ENQUEUE and DEQUEUE take a single instruction each.

Q.42 Consider the C function given below.

```
int f(int j)
{
    static int i = 50;
    int k;
    if (i == j)
    {
        printf("something");
        k = f(i);
        return 0;
    }
    else return 0;
}
```

Which one of the following is **TRUE**?

- (A) The function returns 0 for all values of *j*.
- (B) The function prints the string **something** for all values of *j*.
- (C) The function returns 0 when *j* = 50.
- (D) The function will exhaust the runtime stack or run into an infinite loop when *j* = 50.

Q.43 In designing a computer's cache system, the cache block (or cache line) size is an important parameter. Which one of the following statements is correct in this context?

- (A) A smaller block size implies better spatial locality
- (B) A smaller block size implies a smaller cache tag and hence lower cache tag overhead
- (C) A smaller block size implies a larger cache tag and hence lower cache hit time
- (D) A smaller block size incurs a lower cache miss penalty

Q.44 If the associativity of a processor cache is doubled while keeping the capacity and block size unchanged, which one of the following is guaranteed to be NOT affected?

- (A) Width of tag comparator
- (B) Width of set index decoder
- (C) Width of way selection multiplexor
- (D) Width of processor to main memory data bus

Q.45 The value of a *float* type variable is represented using the single-precision 32-bit floating point format of IEEE-754 standard that uses 1 bit for sign, 8 bits for biased exponent and 23 bits for mantissa. A *float* type variable *X* is assigned the decimal value of -14.25 . The representation of *X* in hexadecimal notation is

- (A) C1640000H
- (B) 416C0000H
- (C) 41640000H
- (D) C16C0000H

- Q.46 In the Newton-Raphson method, an initial guess of $x_0 = 2$ is made and the sequence $x_0, x_1, x_2 \dots$ is obtained for the function

$$0.75x^3 - 2x^2 - 2x + 4 = 0$$

Consider the statements

- (I) $x_3 = 0$.
(II) The method converges to a solution in a finite number of iterations.

Which of the following is TRUE?

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

- Q.47 The product of the non-zero eigenvalues of the matrix

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

is _____.

- Q.48 The probability that a given positive integer lying between 1 and 100 (both inclusive) is NOT divisible by 2, 3 or 5 is _____.

- Q.49 The number of distinct positive integral factors of 2014 is _____

- Q.50 Consider the following relation on subsets of the set S of integers between 1 and 2014. For two distinct subsets U and V of S we say $U < V$ if the minimum element in the symmetric difference of the two sets is in U .

Consider the following two statements:

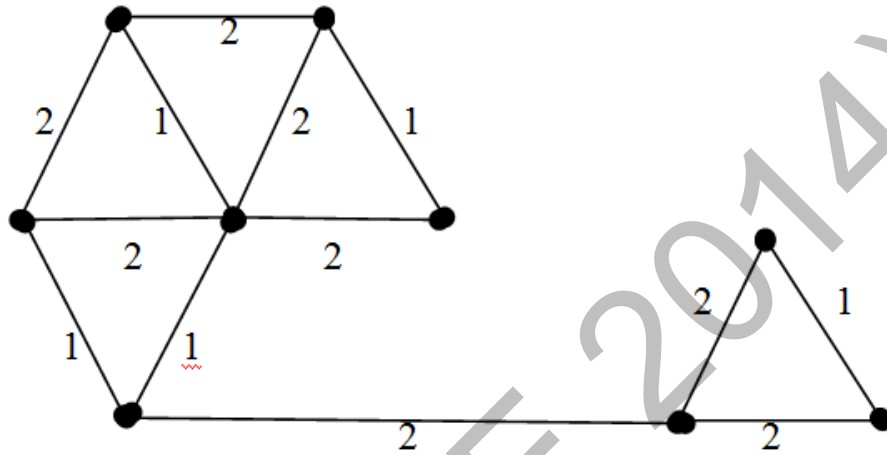
- S1: There is a subset of S that is larger than every other subset.
S2: There is a subset of S that is smaller than every other subset.

Which one of the following is CORRECT?

- (A) Both S1 and S2 are true
(B) S1 is true and S2 is false
(C) S2 is true and S1 is false
(D) Neither S1 nor S2 is true

Q.51 A cycle on n vertices is isomorphic to its complement. The value of n is _____.

Q.52 The number of distinct minimum spanning trees for the weighted graph below is _____



Q.53 Which one of the following Boolean expressions is NOT a tautology?

- (A) $((a \rightarrow b) \wedge (b \rightarrow c)) \rightarrow (a \rightarrow c)$
- (B) $(a \leftrightarrow c) \rightarrow (\neg b \rightarrow (a \wedge c))$
- (C) $(a \wedge b \wedge c) \rightarrow (c \vee a)$
- (D) $a \rightarrow (b \rightarrow a)$

Q.54 SQL allows duplicate tuples in relations, and correspondingly defines the multiplicity of tuples in the result of joins. Which one of the following queries always gives the same answer as the nested query shown below:

```
select * from R where a in (select S.a from S)
```

- (A) `select R.* from R, S where R.a=S.a`
- (B) `select distinct R.* from R,S where R.a=S.a`
- (C) `select R.* from R,(select distinct a from S) as S1 where R.a=S1.a`
- (D) `select R.* from R,S where R.a=S.a and is unique R`


- Q.55 Consider a main memory system that consists of 8 memory modules attached to the system bus, which is one word wide. When a write request is made, the bus is occupied for 100 nanoseconds (ns) by the data, address, and control signals. During the same 100 ns, and for 500 ns thereafter, the addressed memory module executes one cycle accepting and storing the data. The (internal) operation of different memory modules may overlap in time, but only one request can be on the bus at any time. The maximum number of stores (of one word each) that can be initiated in 1 millisecond is _____


END OF THE QUESTION PAPER


CS02 (GATE 2014)


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:

 You have not visited the question yet.

 You have not answered the question.

 You have answered the question.

 You have NOT answered the question, but have marked the question for review.

 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 of $\frac{1}{3}$ marks for a 1-mark question and $\frac{2}{3}$ 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 While trying to collect an envelope from under the table, Mr. X fell down and
I II III
was losing consciousness.
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 $f: X \rightarrow Y$ 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

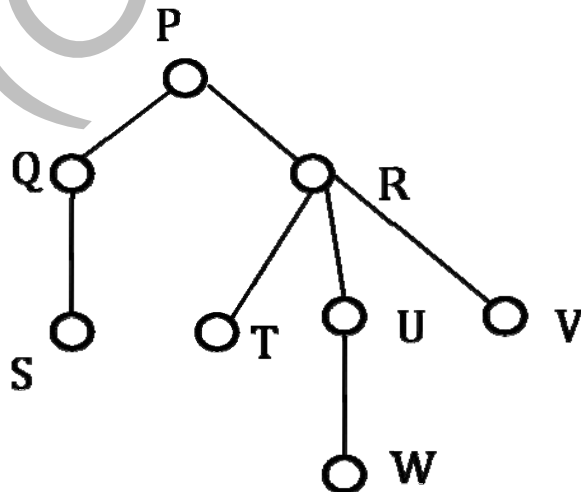
- Q.10 Let A be a square matrix of size $n \times n$. Consider the following pseudocode. What is the expected output?

```

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]);

```

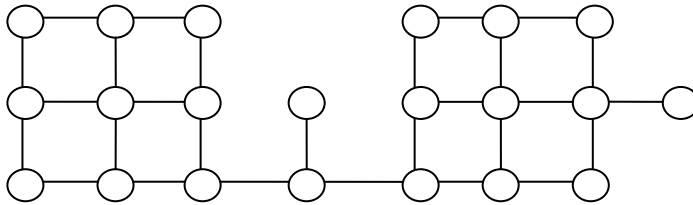
- (A) The matrix A itself
 (B) Transpose of the matrix A
 (C) Adding 100 to the upper diagonal elements and subtracting 100 from lower diagonal elements of A
 (D) None of the above
- Q.11 The minimum number of arithmetic operations required to evaluate the polynomial $P(X) = X^5 + 4X^3 + 6X + 5$ for 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:

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

The above query evaluates to the set of **empIds** 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.

$$\begin{aligned} a &= b + c \\ c &= a + d \\ d &= b + c \\ e &= d - b \\ a &= e + b \end{aligned}$$

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 $\Sigma = \{0,1,c\}$:

$$L_1 = \{0^n 1^n \mid n \geq 0\}$$

$$L_2 = \{wcw^r \mid w \in \{0,1\}^*\}$$

$$L_3 = \{ww^r \mid w \in \{0,1\}^*\}$$

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:

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

For example, $\Phi = (x_1 \vee x_2) \wedge (x_1 \vee \bar{x}_3) \wedge (x_2 \vee x_4)$ 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.

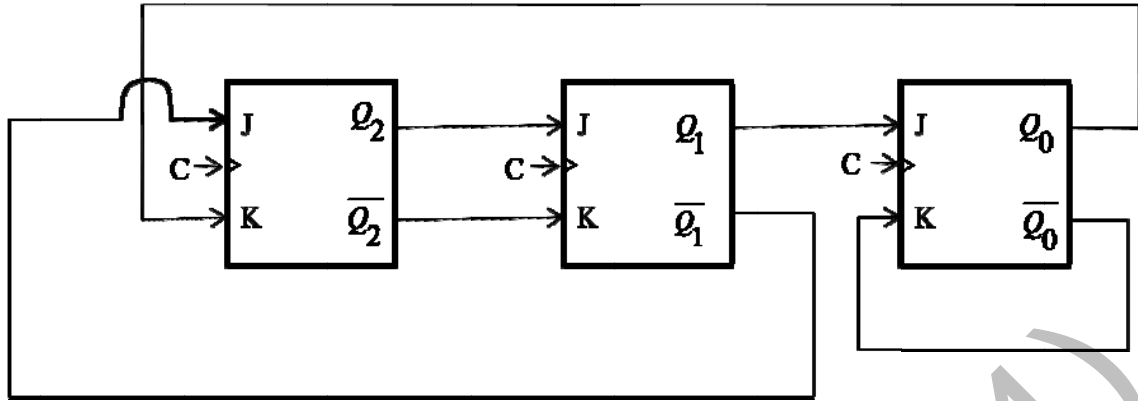
```
int ProcessArray(int *listA, int x, int n)
{
    int i, j, k;
    i = 0;
    j = n-1;
    do {
        k = (i+j)/2;
        if (x <= listA[k])
            j = k-1;
        if (listA[k] <= x)
            i = k+1;
    }while (i <= j);

    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 $f: \{0,1, \dots, 2014\} \rightarrow \{0,1, \dots, 2014\}$ such that $f(f(i)) = i$, for all $0 \leq i \leq 2014$. 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 $\delta \geq 3$, which one of the following is **TRUE**?

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

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

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

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

- 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 :

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

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