GATE 2015

Solved Paper

Computer Science & IT

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Time : 3 hrs **MM :** 100

Read the following instructions carefully

1. There are 65 questions carrying 100 marks of 3 hrs duration in this paper.
2. Questions 1 to 25 carry 1 mark each and questions 26 to 55 carry 2 marks each.
3. Questions 56 to 65 belong to General Aptitude (GA) Type. Questions 56 to 60 carry 1 mark each and questions 61 to 65 carry 2 marks each.
4. Unattempted questions will carry zero marks.
5. For questions 1 to 25 and 56 to 60, 1/3 mark will be deducted for each wrong answer. For questions 26 to 55 and 61 to 65, 2/3 mark will be deducted for each wrong answer.
6. There is no negative marking for numerical answer type questions.
7. Non-programmable type calculator is allowed. Charts, graph sheets and mathematical tables are not allowed in the examination hall.

(1 *Mark Questions*)

1. Match the following lists :

List I	List II
A. Condition coverage	1. Black-box testing
B. Equivalence class partitioning	2. System testing
C. Volume testing	3. White-box testing
D. Alpha testing	4. Performance testing

Codes

(a) A-2, B-3, C-1, D-4
(b) A-3, B-4, C-2, D-1
(c) A-3, B-1, C-4, D-2
(d) A-3, B-1, C-2, D-4

Sol. (d) **Condition coverage** testing to devise a good set of white-box test cases is to consider the control flow of the program. The control flow of the program is represented in a flow graph. We consider various aspects of this flow graph in order to ensure that we have an adequate set of test cases.

The adequacy of the test cases is often measured with a metric called coverage. Coverage is a measure of the completeness of the set of test cases.

Equivalence class Partitioning (EP) is a specification-based or black-box testing technique. It can be applied at any level of testing and is often a good technique to use first.

System testing of software or hardware is a testing conducted on a complete, integrated system to evaluate the system's compliance with its specified requirements. The following examples are different types of testing that should be considered during system testing:

(i) Software performance testing
(ii) Load testing
(iii) Volume testing
(iv) Stress testing
(v) Security testing
(vi) Regression testing
(vii) Maintenance testing
(viii) Recovery testing

2. Which one of the following is the recurrence equation for the worst case time complexity of the quick sort algorithm for sorting $n (\geq 2)$ numbers? In the recurrence equations given in the options below, c is a constant.

(a) $T(n) = 2T(n/2) + cn$

(b) $T(n) = T(n-1) + T(1) + cn$

(c) $T(n) = 2T(n-2) + cn$

(d) $T(n) = T(n/2) + cn$

Sol. (b) $T(n) = T(n-1) + T(1) + cn$

Worst case occurs, when the subarrays are completely unbalanced. There is 1 element in one subarray and $(n-1)$ elements in the other subarray.

3. For any two languages L_1 and L_2 such that L_1 is context free and L_2 is recursively enumerable but not recursive, which of the following is/are necessarily true?

I. L_1' (complement of L_1) is recursive

II. L_2' (complement of L_2) is recursive

III. L_1' is context free

IV. $L_1' \cup L_2$ is recursively enumerable

(a) Only I

(b) Only III

(c) Both III and IV

(d) Both I and IV

Sol. (d) L_1' is context free and hence, recursive also. Recursive set being closed under complement, L_1' will be recursive.

L_1' being recursive it is also recursively enumerable and recursively enumerable set is closed under union. So, $L_1' \cup L_2$ is recursively enumerable.

Context free languages are not closed under complement so, L_1 is not context free.

Recursive set is closed under complement. So, if L_2' is recursive, $(L_2')' = L_2$ is also recursive which is not the case here. So, L_2' is not recursive.

4. $\lim_{x \to \infty} x^{1/x}$ is

(a) ∞ (b) 0

(c) 1 (d) Not defined

Sol. (c) Let $y = \lim_{x \to \infty} x^{1/x}$

$\Rightarrow \ln y = \lim_{x \to \infty} \frac{\ln x}{x}$ [taking logarithms]

$= \lim_{x \to \infty} \frac{1/x}{1}$ $\left[\frac{\infty}{\infty} \text{ form and using L'Hospital's rule}\right]$

$= 0$

$y = 1$

5. If $g(x) = 1 - x$ and $h(x) = \frac{x}{x-1}$, then $\frac{g(h(x))}{h(g(x))}$ is

(a) $\frac{h(x)}{g(x)}$ (b) $\frac{-1}{x}$

(c) $\frac{g(x)}{h(x)}$ (d) $\frac{x}{(1-x)^2}$

Sol. (a) $g(x) = 1 - x,$ ... (i)

$h(x) = \frac{x}{x-1}$ ...(ii)

replace x by $h(x)$ in Eq.(i), replacing x by $g(x)$ in Eq. (ii),

$g\{h(x)\} = 1 - h(x),\ h\{g(x)\} = \frac{g(x)}{g(x)-1} = \frac{1-x}{-x}$

$= 1 - \frac{x}{x-1}$

$= \frac{-1}{x-1}$

$\Rightarrow \quad \frac{g\{h(x)\}}{h\{g(x)\}} = \frac{x}{(x-1)(1-x)} = \frac{\frac{x}{x-1}}{1-x} = \frac{h(x)}{g(x)}$

6. Match the following lists :

	List I		List II
A.	Prim's algorithm for minimum spanning tree	1.	Backtracking
B.	Floyd-Warshall algorithm for all pairs shortest paths	2.	Greedy algorithm
C.	Merge sort	3.	Dynamic programming
D.	Hamiltonian circuit	4.	Divide and conquer

Codes

(a) A-3, B-2, C-4, D-1 (b) A-1, B-2, C-4, D-3

(c) A-2, B-3, C-4, D-1 (d) A-2, B-1, C-3, D-4

Sol. (c) A. In computer science, Prim's algorithm is a greedy algorithm that finds a minimum spanning tree for a connected weighted undirected graph.

B. The Floyd–Warshall algorithm (for all pairs shortest paths) is a graph analysis algorithm for finding shortest paths in a weighted graph with positive or negative edge weights (but with no negative cycles).

This algorithm is an example of dynamic programming.

C. Merge sort on an input sequence S with n elements consists of three steps:

Divide: partition S into two sequences S_1 and S_2 of about $n/2$ elements each

Recur : recursively sort S_1 and S_2

Conquer : merge S_1 and S_2 into a unique sorted sequence

Hence, Merge sort is based on the divide and conquer paradigm.

7. SELECT operation in SQL is equivalent to

(a) the selection operation in relational algebra

(b) the selection operation in relational algebra, except that SELECT in SQL retains duplicates

(c) the projection operation in relational algebra

(d) the projection operation in relational algebra, except that SELECT in SQL retains duplicates

Sol. (d) because SELECT operation in SQL is equivalent to the projection operation in relational algebra, except that SELECT in SQL retains duplicates but projection gives only distinct.

8. For computers based on three address instruction formats, each address field can be used to specify which of the following

S1 A memory operand

S2 A processor register

S3 An implied accumulator register

(a) Either S1 or S2 (b) Either S2 or S3

(c) Both S2 and S3 (d) All of S1, S2 and S3

Sol. (a) Computers with three address instruction formats can use each address field to specify either a memory operand (S1) or a processor register (S2).

9. The following two functions P1 and P2 that share a variable B with an initial value of 2 execute concurrently.

```
P1( )
{
   C = B - 1;
   B = 2 * C;
}
P2( )
{
   D = 2 * B;
   B = D - 1;
}
```

The number of distinct values that B can possibly take after the execution is _____ .

Sol. There are following ways that concurrent processes can follow.

```
C = B – 1;    // C=1
B =2 * C;     // B=2
D = 2 * B;    // D=4
B = D – 1;    // B=3

C = B – 1;    // C=1
D =2 * B;     // D=4
B = D – 1;    // B=3
B = 2 * C;    // B=2

C = B – 1;    // C=1
D = 2 * B;    // D=4
B = 2 * C;    // B=2
B = D – 1;    // B=3

D = 2 * B;    // D=4
C = B – 1;    // C=1
B = 2 * C;    // B=2
B = D – 1;    // B=3

D = 2 * B;    // D=4
B = D – 1;    // B=3
C = B – 1;    // C=2
B = 2 * C;    // B=4
```

There are 3 different possible values of B: 2,3 and 4.

10. Which of the following is/are correct inorder traversal sequence(s) of binary search tree(s)?

I. 3, 5, 7, 8, 15, 19, 25

II. 5, 8, 9, 12, 10, 15, 25

III. 2, 7, 10, 8, 14, 16, 20

IV. 4, 6, 7, 9, 18, 20, 25

(a) Both I and IV (b) Both II and III

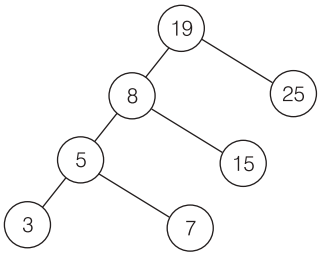
(c) Both II and IV (d) Only II

Sol. (a) A binary search tree is a binary tree with a special property called the BST-property, which is given as follows:

For all nodes x and y, if y belongs to the left subtree of x, then the key at y is less than the key at x and if y belongs to the right subtree of x, then the key at y is greater than the key at x.

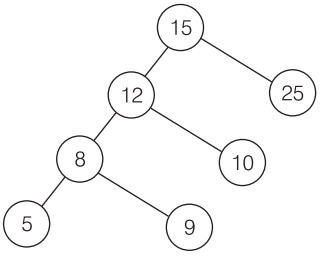
Inorder Traversal The ordering is the left subtree, the current node, the right subtree.

I. 3, 5, 7, 8, 15, 19, 25



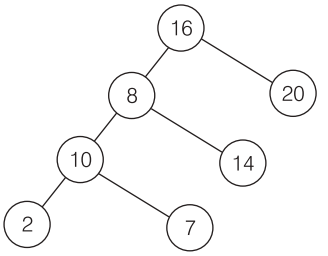
(✓)

II. 5, 8, 9, 12, 10, 15, 25



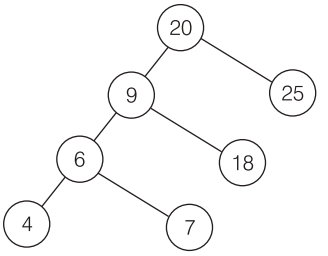
(✗)

III. 2, 7, 10, 8, 14, 16, 20



(✗)

IV. 4, 6, 7, 9, 18, 20, 25



(✓)

or

An inorder traversal of a Binary Search Tree must be in increasing order.

Here, I and IV are correct inorder traversal sequences.

11. The output of the following C program is _____ .

```
void f1 (int a, int b)
{
   int c;
   c=a; a=b; b=c;
}
void f2 (int *a, int *b)
{
   int c;
   c=*a; *a=*b; *b=c;
}
int main( )
{
   int a=4, b=5, c=6;
   f1 (a, b);
   f2 (&b, &c);
   printf("%d", c-a-b);
}
```

Sol. Here, f1 will not change any values because it is call by value but f2 is call by reference and it swaps values of b and c and changes are also reflected in main function. So, c – a – b = 5 – 4 – 6 = –5.

Hence, answer is –5.

12. Consider a system with byte-addressable memory, 32-bit logical addresses, 4 KB page size and Page Table Entries (PTE) of 4 Bytes each. The size of the page table in the system in MB is _____ .

Sol. Total number of entries in page table = $2^{32} / 2^{12} = 2^{20}$

we need a PTE for each page and an entry is 4 Bytes. So, page table size = (number of entries in page table)* (size of an entry)= $2^{20} \times 4$bytes = 2^{22} = 4 MB.

13. Which one of the following is True at any valid state in shift-reduce parsing?

(a) Viable prefixes appear only at the bottom of the stack and not inside

(b) Viable prefixes appear only at the top of the stack and not inside

(c) The stack contains only a set of viable prefixes

(d) The stack never contains viable prefixes

Sol. (c) The prefixes of right sentential forms that can appear on the stack of a shift-reduce parser are called viable prefexes. By definition, a viable prefix is a prefix of a right sentential form that does not continue past the right end of the rightmost handle of that sentential form.

14. Which one of the following is not equivalent to $p \leftrightarrow q$?

(a) $(\neg p \vee q) \wedge (p \vee \neg q)$ (b) $(\neg p \vee q) \wedge (q \rightarrow p)$

(c) $(\neg p \vee q) \vee (p \vee \neg q)$ (d) $(\neg p \wedge \neg q) \vee (p \wedge q)$

Sol. (d) $p \leftrightarrow q$

$= (p \rightarrow q) \wedge (q \rightarrow p)$ [as, $p \rightarrow q = \neg\ p \vee q$]

$= (\neg\ p \vee q) \wedge (q \rightarrow p)$

$= (\neg\ p \vee q) \wedge (\neg\ q \vee p)$

$= (\neg\ p \wedge \neg\ q) \vee (p \wedge q)$

15. Which of following Statement(s) is/are incorrect?

I. XML overcomes the limitations in HTML to support a structured way of organising content.

II. XML specification is not case sensitive while HTML specification is case sensitive.

III. XML supports user defined tags while HTML uses pre-defined tags.

IV. XML tags need not be closed while HTML tags must be closed.

(a) Only II (b) Only I

(c) Both II and IV (d) Both III and IV

Sol. (c)

16. For a set A, the power set of A is denoted by 2^A. If $A = \{5, \{6\}, \{7\}\}$, which of the following options are correct?

I. $\phi \in 2^A$ II. $\phi \subseteq 2^A$

III. $\{5, \{6\}\} \in 2^A$ IV. $\{5, \{6\}\} \subseteq 2^A$

(a) Both I and III (b) Both II and III

(c) I, II and III (d) I, II and IV

Sol. (c) ϕ is subset of every set.

ϕ is the first element of the power set $\{5,\{6\}\} \subseteq A$

17. In one of the pairs of protocols given below, both the protocols can use multiple TCP connections between the same client and the server. Which one is that?

(a) HTTP, FTP (b) HTTP, TELNET

(c) FTP, SMTP (d) HTTP, SMTP

Sol. (a) **SMTP** Only one TCP connection.

TELNET Only one TCP connection.

HTTP Multiple TCP connections can be used for each resource.

FTP FTP uses two TCP connections, one for control info and another for data exchange.

18. In the LU decomposition of the matrix $\begin{bmatrix} 2 & 2 \\ 4 & 9 \end{bmatrix}$, if the diagonal elements of U are both 1, then the lower diagonal entry l_{22} of L is _____ .

Sol. $A = LU \Rightarrow \begin{bmatrix} 2 & 2 \\ 4 & 9 \end{bmatrix} = \begin{bmatrix} l_{11} & 0 \\ l_{21} & l_{22} \end{bmatrix} \begin{bmatrix} 1 & u_{12} \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} l_{11} & l_{11}\, u_{12} \\ l_{21} & l_{21}\, u_{12} + l_{22} \end{bmatrix}$

$\therefore \quad l_{11} = 2; l_{11}u_{12} = 2 \Rightarrow u_{12} = 1$

$l_{21} = 4; l_{21}u_{12} + l_{22} = 9 \Rightarrow l_{22} = 5$

The l_{22} of l is 5.

19. Suppose, two hosts use a TCP connection to transfer a larger file. Which of the following Statement(s) is/are incorrect with respect to TCP connection?

I. If the sequence number of a segment is m, then the sequence number of the subsequent segment is always $m + 1$.

II. If the estimated round trip time at any given point of time is t sec, the value of the retransmission timeout is always set to greater than or equal to t sec.

III. The size of the advertised window never changes during the course of the TCP connection.

IV. The number of unacknowledged bytes at the sender is always less than or equal to the advertised window.

(a) Only III (b) Both I and III

(c) Both I and IV (d) Both II and IV

Sol. (b)

20. Consider a 4-bit Johnson counter with an initial value of 0000. The counting sequence of this counter is

(a) 0, 1, 3, 7, 15, 14, 12, 8, 0

(b) 0, 1, 3, 5, 7, 9, 11, 13, 15, 0

(c) 0, 2, 4, 6, 8, 10, 12, 14, 0

(d) 0, 8, 12, 14, 15, 7, 3, 1, 0

Sol. (d) 0000 - 0

1000 - 8

1100 - 12 and so on.

21. Suppose, that everyone in a group of N people wants to communicate secretly with the $N-1$ others using symmetric key cryptographic system. The communication between any two persons should not be decodable by the others in the group. The number of keys required in the system as a whole to satisfy the confidentiality requirement is

(a) $2N$ (b) $N(N-1)$

(c) $N(N-1)/2$ (d) $(N-1)^2$

Sol. (c) In symmetric key cryptographic system, both parties have access to key. So, the first person has $N-1$ keys with other $N-1$ people, second one has another $N-2$ with $N-2$ people (1 we already considered) and so on till 1. So, total number of keys required

$= N-1+N-2+\ldots+1$

$= N(N-1)/2$

22. Which one of the following fields of an IP header is not modified by a typical IP router?

(a) Checksum (b) Source address

(c) Time To Live (TTL) (d) Length

Sol. (b)

23. What are the worst case complexities of insertion and deletion of a key in a binary search tree?

(a) $\theta(\log n)$ for both insertion and deletion

(b) $\theta(n)$ for both insertion and deletion

(c) $\theta(n)$ for insertion and $\theta(\log n)$ for deletion

(d) $\theta(\log n)$ for insertion and $\theta(n)$ for deletion

Sol. (b) Both happen when the BST is skewed.

24. A file is organised so, that the ordering of data records is the same as or close to the ordering of data entries in some index. Then that index is called

(a) Dense (b) Sparse

(c) Clustered (d) Unclustered

Sol. (c) **Clustered** This is the definition of clustered indexing and for the same reason a table can have only one clustered index.

25. The height of a tree is the length of the longest root-to-leaf path in it. The maximum and minimum number of nodes in a binary tree of height 5 are

(a) 63 and 6, respectively

(b) 64 and 5, respectively

(c) 32 and 6, respectively

(d) 31 and 5, respectively

Sol. (a) because height 5 means level 1, so maximum node $= 2^6 - 1 = 63$ and for minimum, at each level only single node so, total is 6.

(2 Marks Questions)

26. $\sum_{x=1}^{99} \frac{1}{x(x+1)} =$ _____ .

Sol. $\sum_{x=1}^{99} \frac{1}{x(x+1)} = \frac{1}{1(2)} + \frac{1}{2(3)} + \frac{1}{3(4)} + \ldots\ldots + \frac{1}{99(100)}$

$$= \frac{2-1}{1(2)} + \frac{3-2}{2(3)} + \frac{4-3}{3(4)} + \ldots\ldots + \frac{100-99}{99(100)}$$

$$= \frac{1}{1} - \frac{1}{2} + \frac{1}{2} - \frac{1}{3} + \frac{1}{3} + \ldots\ldots + \frac{1}{98} - \frac{1}{99} + \frac{1}{99} - \frac{1}{100}$$

$$= 1 - \frac{1}{100} = \frac{99}{100} = 0.99$$

27. Consider the following relations:

Student

Roll_No	Student_Name
1	Raj
2	Rohit
3	Raj

Performance

Roll_No	Course	Marks
1	Math	80
1	English	70
2	Math	75
3	English	80
2	Physics	65
3	Math	80

Consider the following SQL query.

SELECT S.Student_Name, sum (P.Marks)

FROM Student S, Performance P

WHERE S.Roll_No = P.Roll_No

GROUP BY S.Student_Name

The number of rows that will be returned by the SQL query is _____ .

Sol. The output of the given SQL query is as follows:

```
+--------------+--------------+
|Student_Name  |sum(p.Marks)  |
+--------------+--------------+
|Raj           |          310 |
|Rohit         |          140 |
+--------------+--------------+
2 rows in set (0.07 sec)
```

Hence, the number of rows that will be returned by the given SQL query is 2.

28. The binary operator $\neq$ is defined by the following truth table.

p	q	$p \neq q$
0	0	0
0	1	1
1	0	1
1	1	0

Which one of the following is correct about the binary operator $\neq$?

(a) Both commutative and associative

(b) Commutative but not associative

(c) Not commutative but associative

(d) Neither commutative nor associative

Sol. (a) As it is XOR operation

29. Consider a LAN with four nodes S_1, S_2, S_3 and S_4. Time is divided into fixed-size slots and a node can begin its transmission only at the beginning of a slot. A collision is said to have occurred if more than one node transmit in the same slot. The probabilities of generation of a frame in a time slot by S_1, S_2, S_3 and S_4 are 0.1, 0.2, 0.3 and 0.4, respectively. The probability of sending a frame in the first slot without any collision by any of these four stations is _____ .

Sol. The answer is 0.462.

30. Suppose, the following disk request sequence (track numbers) for a disk with 100 tracks is given : 45, 20, 90, 10, 50, 60, 80, 25, 70. Assume that the initial position of the R/W head is on track 50.

The additional distance that will be traversed by the R/W head when the Shortest Seek Time First (SSTF) algorithm is used compared to the SCAN (Elevator) algorithm (assuming that SCAN algorithm moves towards 100 when it starts execution) is _____ tracks.

Sol. **SSTF**

Initial position= 50

So, shortest sequence will be

50, 45, 60, 70, 80, 90, 25, 20, 10

and the corresponding distances will be

0, 5, 15, 10, 10, 10, 65, 5, 10

Giving total distance

$= 0 + 5 + 15 + 10 + 10 + 10 + 65 + 5 + 10$

$= 130.$

SCAN

Here, requests from 50 are serviced in ascending order of their track number (as the movement is from 50 to 100) and at the end of the sequence, the remaining requests are serviced in the descending order. So, the service order will be

50, 60, 70, 80, 90, 45, 25, 20, 10

and the corresponding distances

0, 10, 10, 10, 10, 45, 20, 5, 10

giving a total distance of 120

So, extra distance of SSTF = 130 – 120 = 10

31. Consider the following C function.

```
int fun1 (int n)
{
   int i, j, k, p, q = 0;
   for (i=1; i<n; ++i)
   {
      p = 0;
      for ( j=n; j>1; j=j/2)
           ++p;
      for (k=1; k<p; k=k*2)
           ++q;
   }
   return q;
}
```

Which one of the following most closely approximates the return value of the function fun1?

(a) n^3

(b) $n(\log n)^2$

(c) $n \log n$

(d) $n \log (\log n)$

Sol. (d) i loop is executing n times. j loop is executing log n times for each i and so, value of p is log n. k loop is executing log p times, which is log log n times for each iteration of i. In each of these q is incremented. So, over all iterations of i, q will be incremented n log(log n) times.

32. Consider a max heap, represented by the array : 40, 30, 20, 10, 15, 16, 17, 8, 4.

Array Index	1	2	3	4	5	6	7	8	9
Value	40	30	20	10	15	16	17	8	4

Now, consider that a value 35 is inserted into this heap. After insertion, the new heap is

(a) 40, 30, 20, 10, 15, 16, 17, 8, 4, 35

(b) 40, 35, 20, 10, 30, 16, 17, 8, 4, 15

(c) 40, 30, 20, 10, 35, 16, 17, 8, 4, 15

(d) 40, 35, 20, 10, 15, 16, 17, 8, 4, 30

Sol. (b) Heap is complete binary tree. To insert a new element, we put it at the end of the tree and move up towards root till heap property is satisfied.

Here, 35 come as child of 15, with the path 40-30-15-35. So, we swap 15, 35 and then 30, 35 to get the new path 40-35-30-15. So, new heap will be 40, 35, 20, 10, 30, 16, 17, 8, 4, 15.

33. Consider the following pseudo code, where x and y are positive integers.

```
begin
   q := 0
   r := x
   while r ≥ y do
   begin
      r := r - y
      q := q + 1
   end
end
```

The post condition that needs to be satisfied after the program terminates is

(a) $\{r = qx + y \wedge r < y\}$

(b) $\{x = qy + r \wedge r < y\}$

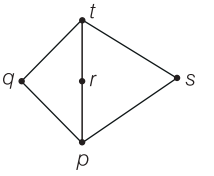
(c) $\{y = qx + r \wedge 0 < r < y\}$

(d) $\{q + 1 < r - y \wedge y > 0\}$

Sol. (b) The loop terminates when r < y. So, r < y is one post condition.

In each iteration, q is incremented by 1 and y is subtracted from r. Initial value of r is x. So, loop iterates x/y times and q will be equal to x/y and $r = x\%y \Rightarrow x = qy + r$.

34. Suppose, $L = \{p, q, r, s, t\}$ is a lattice represented by the following Hasse diagram :



For any xyeL, not necessarily distinct, $x \vee y$ and $x \wedge y$ are join and meet of x, y, respectively. Let $L^3 = \{(x, y, z) : x, y, z \in L\}$ be the set of all ordered triplets of the elements of L. Let p_r be the probability that an element $(x, y, z) \in L^3$ chosen equiprobably satisfies $x \vee (y \wedge z) = (x \vee y) \wedge (x \vee z)$. Then.

(a) $p_r = 0$

(b) $p_r = 1$

(c) $0 < p_r \leq 1/5$

(d) $1/5 < p_r < 1$

Sol. (d)

35. What is the output of the following C code? Assume that the address of x is 2000 (in decimal) and an integer requires four bytes of memory.

```
int main( )
{
   unsigned int x [4] [3] =
   {{1, 2, 3},{4, 5, 6},{7, 8, 9},{10, 11, 12}};
   printf("%u, %u, %u", x+3, *(x+3), *(x+2)+3);
}
```

(a) 2036, 2036, 2036
(b) 2012, 4, 2204
(c) 2036, 10, 10
(d) 2012, 4, 6

Sol. (a) Address of x is 2000.
x being a 2-D array,
$x + 3 = x + 3$ * size of its inner dimension
$= 2000 + 3 \times 3 \times 4$ [as inner dimension is 3 integers of size 4]
$= 2000 + 36 = 2036$
$*(x + 3)$ returns the value at address 2036.
But, since x is 2-D array, one * will just return the 1-D array which is the starting address of it, which is 2036 only.
$(x + 2) = 2000 + 2 \times 3 \times 4 = 2024$
$*(x + 2) + 3 = 2024 + 3 \times 4 = 2036$ [the * changes the data type from 2-D to 1-D and hence, + 3 will add 3 * 4 and not 3 * 3 * 4]

36. Consider the following 2×2 matrix A where, two elements are unknown and are marked by a and b. The eigenvalues of this matrix are –1 and 7. What are the values of a and b?

$$A = \begin{bmatrix} 1 & 4 \\ b & a \end{bmatrix}$$

(a) $a = 6, b = 4$ (b) $a = 4, b = 6$
(c) $a = 3, b = 5$ (d) $a = 5, b = 3$

Sol. (d) Given, $\lambda_1 = -1$ and $\lambda_2 = 7$ are eigenvalues of A
By properties,
$\lambda_1 + \lambda_2 = \text{tr}(A)$ and $\lambda_1 \cdot \lambda_2 = |A|$
(trace of A i.e. sum of the diagonal elements; determinant of A)
$\Rightarrow \quad 6 = 1 + a$ and $-7 = a - 4b$
$\Rightarrow \quad a = 5 \quad \Rightarrow \quad -7 = 5 - 4b$
$\Rightarrow \quad b = 3$

37. A positive edge-triggered D flip-flop is connected to a positive edge-triggered JK flip-flop as follows. The Q output of the D flip-flop is connected to both the J and K inputs of the JK flip-flop, while the Q output of the JK flip-flop is connected to the input of the D flip-flop. Initially, the output of the D flip-flop is set to logic one and the output of the JK flip-flop is cleared.
Which one of the following is the bit sequence (including the initial state) generated at the Q output of the JK flip-flop when the flip-flops are connected to a free-running common clock? Assume that $J = K = 1$ is the toggle mode and $J = K = 0$ is the state-holding mode of the JK flip-flop. Both the flip-flops have non-zero propagation delays.
(a) 0110110… (b) 0100100…
(c) 011101110… (d) 011001100…

Sol. (a)

Q_{prev}	D	Q
-	1	0
0	0	1
1	1	1
1	1	0
0	0	1
1	1	1

D flip-flop outputs its input and JK flip-flop output toggles its output when 1 is given to both J and K inputs.

$$Q = D_{prev}(Q_{prev}') + (D_{prev}')Q_{prev}$$

38. Consider a non-pipelined processor with a clock rate of 2.5 GHz and average cycles per instruction of four. The same processor is upgraded to a pipelined processor with five stages; but due to the internal pipeline delay, the clock speed is reduced to 2 GHz. Assume that there are no stalls in the pipeline. The speed up achieved in this pipelined processor is _____ .

Sol. Speed up = Old execution time/New execution time
$= CPI_{old}/CF_{old}/(CPI_{new}/CF_{new})$ where, (CF is Clock Frequency and CPI is Cycles Per Instruction, so CPI/CF gives time per instruction)
$= 4/2.5/(1/2) = 3.2$
Without pipelining an instruction was taking 4 cycles. After pipelining to 5 stages we need to see the max. Clock cycle a stage can take and this will be the CPI assuming no stalls.

39. Consider the operations

$$f(X, Y, Z) = X'YZ + XY'$$

and $\quad g(X'YZ) = X'YZ + X'YZ' + XY$

Which one of the following is correct?
(a) Both $\{f\}$ and $\{g\}$ are functionally complete
(b) Only $\{f\}$ is functionally complete
(c) Only $\{g\}$ is functionally complete
(d) Neither $\{f\}$ nor $\{g\}$ is functionally complete

Sol. (b) g is preserving 0 as when all inputs are zero, output is always 0 and so, g cannot be functionally complete. f is not preserving 0.

f is not preserving 1. (when all inputs are 1, output is 0).

f is not linear as in XY' only one (odd) input needs to be 1 and in $X'YZ$ two inputs (even) needs to be 1.

f is not monotone as changing Y from 0 to 1, can take f from 1 to 0.

f is not self dual as $f(X, Y, Z) \neq \neg f(\neg X, \neg Y, \neg Z)$

So, f satisfies all 5 conditions required for functional completeness and hence, (b) is the answer.

40. An algorithm performs $(\log N)^{1/2}$ find operations, N insert operations, $(\log N)^{1/2}$ operations and $(\log N)^{1/2}$ decrease-key operations on a set of data items with keys drawn from a linearly ordered set. For a delete operation, a pointer is provided to the record that must be deleted. For the decrease-key operation, a pointer is provided to the record that has its key decreased. Which one of the following data structures is the most suited for the algorithm to use, if the goal is to achieve the best total asymptotic complexity considering all the operations?

(a) Unsorted array

(b) Min heap

(c) Sorted array

(d) Sorted doubly linked list

Sol. (a) Number of insert operations is the significant one here.

For N insert operations,

Unsorted array: $O(N)$

Min heap: $O(N \log N)$

Sorted array: $O(N \log N)$

Sorted doubly linked list: $O(N \log N)$.

So, unsorted array is the answer.

41. Consider an Entity Relationship (ER) model in which entity sets E_1 and E_2 are connected by an $m:n$ relationship R_{12}, E_1 and E_3 are connected by a $1:n$ (1 on the side of E_1 and n on the side of E_3) relationship R_{13}.

E_1 has two single-valued attributes a_{11} and a_{12} of which a_{11} is the key attribute. E_2 has two single-valued attributes a_{21} and a_{22} is the key attribute. E_3 has two single-valued attributes a_{31} and a_{32} of which a_{31} is the key attribute. The relationship do not have any attributes.

If a relational model is derived from the above ER model, then the minimum number of relations that would be generated if all the relations are in 3NF is _____ .

Sol. The relations are as shown:

$<a_{11}, a_{12}>$ for E_1

$<a_{21}, a_{22}>$ for E_2

$<a_{12}, a_{32}, a_{11}>$ for E_3 and $E_1 - E_3$ relationship

$<a_{11}, a_{21}>$ for m:n relationship $E_1 - E_2$

We cannot combine any relation here, as it will give rise to partial functional dependency and thus violate 3NF.

Answer is 4

42. Consider the following C program segment.

```
while (first <= last)
{
   if (array [middle] < search)
      first = middle + 1;
   else if (array [middle] == search)
      found = True;
   else
      last = middle - 1;
      middle = (first + last)/2;
}
if (first < last) not Present = True;
```

The cyclomatic complexity of the program segment is _____ .

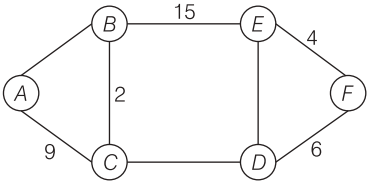
Sol. Number of predicates = 4, if, else if, while and if.

Cyclomatic complexity = number of predicates + 1 = 5.

43. The graph shown below 8 edges with distinct integer edge weights. The Minimum Spanning Tree (MST) is of weight 36 and contains the edges :

$\{(A, C), (B, C), (B, E), (E, F), (D, F)\}$.

The edge weights of only those edges which are in the MST are given in the figure shown below. The minimum possible sum of weights of all 8 edges of this graph is _____ .



Sol. Consider the cycle ABC, AC and AB are part of minimum spanning tree. So, AB should be greater than maximum (AC, BC) (greater and not equal as edge weights are given to be distinct), as otherwise we could add AB to the minimum spanning tree and removed the greater of AC, BC and we could have got another minimum spanning tree. So, $AB > 9$.

Similarly, for the cycle DEF, $ED > 6$.

And for the cycle $BCDE$, $CD > 15$.

So, minimum possible sum of these will be $10 + 7 + 16 = 33$. Adding the weight of spanning tree, we get the total sum of edge weights = $33 + 36 = 69$.

44. $\int_{1/\pi}^{2/\pi} \frac{\cos(1/x)}{x^2}\,dx =$ _____ .

Sol. $\int_{1/\pi}^{2/\pi} \frac{\cos(1/x)}{x^2}dx$ put $1/x = t$

$= \int_{\pi/2}^{\pi} \cos t\,dt \quad \Rightarrow \quad \frac{-1}{x^2}dx = dt$

and $x = 2/\pi \Rightarrow t = \pi/2$

$x = 1/\pi \Rightarrow t = \pi \qquad \left[\because \int_a^b f(x)dx = -\int_b^a f(x)dx\right]$

$= [\sin t]_{\pi/2}^{\pi} = \sin\pi - \sin(\pi/2) = -1$

45. Let $G = (V, E)$ be a simple undirected graph and s be a particular vertex in it called the source. For $x \in V$, let $d(x)$ denote the shortest distance in G from s to x. A Breadth First Search (BFS) is performed starting at s. Let T be the resultant BFS tree. If (u, v) is an edge of G that is not in T, then which one of the following cannot be the value of $d(u) - d(v)$?

(a) -1 (b) 0 (c) 1 (d) 2

Sol. (d) $d(u) - d(v) = 0$ is possible when both u and v have an edge from t and t is in the shortest path from s to u or v.

$d(u) - d(v) = 1$ is possible when u is in the shortest path from s to v and t is also in the shortest path from s to v and both t and s are siblings-same distance from s to both t and u causing $t - v$ edge to be in BFS tree and not $u - v$. $d(u) - d(v) = -1$ is possible as explained above by interchanging u and v.

$d(u) - d(v) = 2$ is not possible. This is because on BFS traversal we either visit u first or v.

Let's take u first. Now, we put all neighbours of u on queue. Since, v is a neighbour and v is not visited before as assumed, $d(v)$ will become $d(u) + 1$. Similarly, for v being visited first.

46. Consider a uniprocessor system executing three tasks $T1, T2$ and $T3$, each of which is composed of an infinite sequence of jobs (or instances) which arrive periodically at intervals of 3, 7 and 20 ms, respectively. The priority of each task is the inverse of its period and the available tasks are scheduled in order of priority with the highest priority task scheduled first. Each instance of $T1, T2$ and $T3$ requires an execution time of 1, 2 and 4 ms, respectively. Given that all tasks initially arrive at the beginning of the 1st ms and task preemptions are allowed, the first instance of $T3$ completes its execution at the end of _____ ms.

Sol.
1 : $T1$
2 : $T2$
3 : $T2$
4 : $T1$
5 : $T3$
6 : $T3$
7 : $T1$
8 : $T2$
9 : $T2$
10 : $T1$
11 : $T3$
12 : $T3$ [first instance of $T3$ completes 4 ms and finished execution]. So, answer is 12.

47. Consider a main memory with five page frames and the following sequence of page references : 3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3. Which one of the following is true with respect to page replacement policies First-In-First-Out (FIFO) and Least Recently Used (LRU)?

(a) Both incur the same number of page faults
(b) FIFO incurs 2 more page faults than LRU
(c) LRU incurs 2 more page faults than FIFO
(d) FIFO incurs 1 more page faults than LRU

Sol. (a) **FIFO**

3 -3 :1 page fault
8 -3 8 : 2 page faults
2 -3 8 2 : 3 page faults
3 -3 8 2 : 3 page faults
9 -3 8 2 9 : 4 page faults
1 -3 8 2 9 1 : 5 page faults
6 -8 2 9 1 6 : 6 page faults
3 -2 9 1 6 3 : 7 page faults
8 -9 1 6 3 8 : 8 page faults
9 -9 1 6 3 8 : 8 page faults
3 -9 1 6 3 8 : 8 page faults
6 -9 1 6 3 8 : 8 page faults
2 -1 6 3 8 2 : 9 page faults
1 -1 6 3 8 2 : 9 page faults
3 -1 6 3 8 2 : 9 page faults
15 page faults are incur

LRU

3 -3 : 1 page fault
8 -3 8 : 2 page faults
2 -3 8 2 : 3 page faults
3 -8 2 3 : 3 page faults
9 -8 2 3 9 : 4 page faults
1 -8 2 3 9 1 : 5 page faults
6 -2 3 9 1 6 : 6 page faults
3 -2 9 1 6 3 : 6 page faults
8 -9 1 6 3 8 : 7 page faults
9 -1 6 3 8 9 : 7 page faults
3 -1 6 8 9 3 : 7 page faults
6 -1 8 9 3 6 : 7 page faults
2 -8 9 3 6 2 : 8 page faults
1 -9 3 6 2 1 : 9 page faults
3 -9 6 2 1 3 : 9 page faults
15 page faults are incur

48. Consider a disk pack with a seek time of 4 ms and rotational speed of 10000 Rotations Per Minute (RPM). It has 600 sectors per track and each sector can store 512 bytes of data. Consider a file stored in the disk. The file contains 2000 sectors. Assume that every sector access necessitates a seek and the average rotational latency for accessing each sector is half of the time for one complete rotation. The total time (in ms) needed to read the entire file is _____ .

Sol. Since, each sector requires a seek,

Total time = 2000 * (Seek Time + Average Rotational Latency + Data Transfer Time)

Since, data transfer rate is not given, we can take that in 1 rotation, all data in a track is read.

i.e. in 60/10000 = 6 ms, 600 * 512 bytes are read.

So, time to read 512 bytes = 6/600 ms = 0.01 ms

= 2000 * (4 ms + 60 * 1000 /2* 10000 + 0.01)

= 2000 * (7.01 ms) = 14020 ms.

49. Let a_n represent the number of bit strings of length n containing two consecutive 1s. What is the recurrence relation for a_n?

(a) $a_{n-2} + a_{n-1} + 2^{n-2}$ (b) $a_{n-2} + 2a_{n-1} + 2^{n-2}$

(c) $2a_{n-2} + a_{n-1} + 2^{n-2}$ (d) $2a_{n-2} + 2a_{n-1} + 2^{n-2}$

Sol. (a) Counting the number of bit strings not containing two consecutive 1's.

0 1

00 01 10 - 3

000 001 010 100 101 - 5 (all strings ending in 0 give two strings and those ending in 1 give 1 string)

0000 0001 0010 0100 0101 1000 1001 1010 - 8

....

$$a_n' = a'_{n-1} + a'_{n-2}$$

$$2^n - a_n = (2^{n-1} - a_{n-1}) + (2^{n-2} - a_{n-2})$$

$$a_n = 2^n - 2^{n-1} - 2^{n-2} + a_{n-1} + a_{n-2}$$

$$= 2^{n-2}(2^2 - 2^1 - 1) + a_{n-1} + a_{n-2}$$

$$a_n = 2^{n-2}\ (4 - 2 - 1) + a_{n-1} + a_{n-2}$$

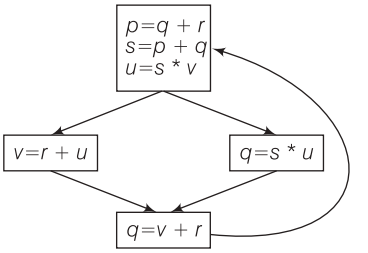
$$a_n = a_{n-1} + a_{n-2} + 2^{n-2}$$

50. A variable x is said to be live at a Statement S_i in a program if the following three conditions hold simultaneously

I. There exists a Statement S_j that uses x.

II. There is a path from S_i to S_j in the flow graph corresponding to the program.

III. The path has no intervening assignment to x including at S_i and S_j.



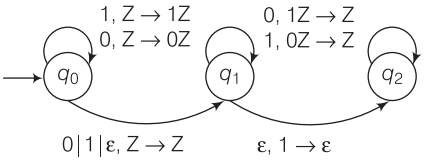
The variables which are live both at the Statement in basic block 2 and at the Statement in basic block 3 of the above control flow grap h are

(a) p, s, u (b) r, s, u

(c) r, u (d) q, v

Sol. (c)

51. Consider the NPDA $\langle Q = \{q_0, q_1, q_2\},\ \Sigma = \{0,1\},\ T = \{0,1,\perp\},\ \delta, q_0, \perp, F = \{q_2\}\rangle$, where (as per usual convention) Q is the set of states, Σ is the input alphabet, T is the stack alphabet, δ is the state transition function, q_0 is the initial state, $\perp$ is the initial stack symbol and F is the set of accepting states. The state transition is as follows:



Which one of the following sequences must follow the string 101100 so, that the overall string is accepted by the automation?

(a) 10110

(b) 10010

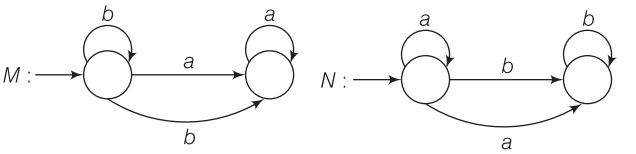
(c) 01010

(d) 01001

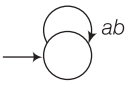
Sol. (b) The given PDA is accepting all strings of the form $x0x_r'$ or $x1x_r'$ where x_r' is the reverse of the 1's complement of x.

The given string 101100 has 6 letters and we are given 5 letter strings. So, x0 is done, with x = 10110. So, $x_r' = (01001)_r = 10010$.

52. Consider the DFAs (Deterministic Finite Automata) M and N given below. The number of state(s) in a minimal DFA that accepts the language $L(M) \cap L(N)$ is(are) _____ .



Sol. $L(M) = (a+b)^* a = \{a, aa, ba, aaa, aba, bba, .\}$
$L(N) = (a+b)^* b = \{b, ab, bb, aab, abb, bbb, ...\}$
So, $L(M) \cap L(N) = \{\}$.For an empty language, only one state is required in DFA. The state is non-accepting and remains on itself for all characters of alphabet.



53. Suppose that the stop and wait protocol is used on a link with a bit rate of 64 Kbps and 20 ms propagation delay. Assume that the transmission time for the acknowledgement and the processing time at nodes are negligible. Then, the minimum frame size in bytes to achieve a link utilisation of atleast 50% is _____ .

Sol. Link utilisation = Amount of data sent/Max. amount of data that could be sent.
Let x be the frame size in bits.
In stop and wait protocol, once a frame is sent, next frame won't be sent until ACK is received. Time for this,
RTT (Round-Trip-Time) = Propagation delay for frame + Transmission time for frame + Propagation delay for ACK + Transmission time for ACK
= 20 ms + x/64 ms + 20 ms + 0 (as given in question)
= (40 + x/64) ms.
Amount of data sent during RTT = x
Maximum amount of data that could be sent = (40 + x/64) × 64 = 2560 + x bits.
So, link utilisation, 0.5 = x/(2560 + x)
x = 2560 bits = 320 bytes

54. Let G be a connected planar graph with 10 vertices. If the number of edges on each face is three, then the number of edges in G is _____ .

Sol. By Euler's formula,

$$|V| + |R| = |E| + 2 \quad \ldots(i)$$

where $|V|$, $|R|$, $|E|$ are respectively number of vertices, edge and faces (regions)

Given $|V| = 10$ ...(ii)

and number of edges on each face is three

$$\therefore \quad 3|R| = 2|E| \Rightarrow |R| = \frac{2}{3}|E| \quad \ldots(iii)$$

Substituting Eqs. (ii), (iii) in (i), we get

$$10 + \frac{2}{3}|E| = |E| + 2 \Rightarrow \frac{|E|}{3} = 8 \Rightarrow |E| = 24$$

55. The least number of temporary variables required to create a three-address code in static single assignment form for the expression $q + r/3 + s - t * 5 + u * v/w$ is _____ .

Sol. Answer should be 8. We will need a temporary variable for storing the result of each binary operation and SSA (Static Single Assignment) implies the variable cannot be repeated.

```
q + r / 3 + s – t * 5 + u * v/w
t1 = r/3;
t2 = t*5;
t3 = u*v;
t4 = t3/w;
t5 = q + t1;
t6 = t5 + s;
t7 = t5 – t2;
t8 = t7 + t4
```

General Aptitude (GA) Questions

(1 *Mark Questions*)

56. Did not you buy _____ when you went shopping?
(a) any paper
(b) much paper
(c) no paper
(d) a few paper

Sol. (a) Did not you buy any paper, when you went spopping?

57. Which of the following options is the closet in meaning to the sentence below?
She enjoyed herself immensely at the party.
(a) She had a terrible time at the party.
(b) She had a horrible time at the party.
(c) She had a terrific time at the party.
(d) She had a terrifying time at the party.

Sol. (c) Ther correct sentence is "She had a terrific time at the party".

58. Given set $A = \{2, 3, 4, 5\}$ and set $B = \{11, 12, 13, 14, 15\}$, two numbers are randomly selected, one from each set. What is the probability that the sum of the two numbers equals 16?
(a) 0.20
(b) 0.25
(c) 0.30
(d) 0.33

Sol. (a) $4 \times 5 = 20$ Total mass

$$\left.\begin{matrix}5,11\\4,12\\3,13\\2,12\end{matrix}\right\} 4 \text{ favorable}$$

$$\therefore \quad \frac{4}{20} = \frac{1}{5} = 0.2$$

59. Based on the given Statements, select the most appropriate option to solve the given question. If two floors in a certain building are 9 feet apart, how many steps are there in a set of stairs that extends from the first floor to the second floor of the building?

Statements

I. Each step is 3/4 foot high.

II. Each step is 1 foot wide.

(a) Statement I alone is sufficient, but Statement II alone is not sufficient.

(b) Statement II alone is sufficient, but Statement I alone is not sufficient.

(c) Both Statements together are sufficient, but neither Statement alone is sufficient.

(d) Statement I and II together are not sufficient.

Sol. (a)

60. Which one of the following combinations is incorrect?

(a) Acquiescence-Submission

(b) Wheedle-Roundabout

(c) Flippancy-Lightness

(d) Profligate-Extravagant

Sol. (b) In which incorrect combination is Wheedle – Roundabout.

(2 Marks Questions)

61. The number of students in a class who have answered correctly, wrongly, or not attempted each question in an exam, are listed in the table below. The marks for each question are also listed. There is no negative or partial marking.

Q.No.	Marks	Answered Correctly	Answered Wrongly	Not Attempted
1	2	21	17	6
2	3	15	27	2
3	1	11	29	4
4	2	23	18	3
5	5	31	12	1

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

(a) 2.290 (b) 2.970

(c) 6.795 (d) 8.795

Sol. (b) $\frac{21\times2+15\times3+11\times1+23\times2+31\times5}{21+15+11+23+31}=2.970$

62. Select the alternative meaning of the underlined part of the sentence.

The chain snatchers **took to their heels** when the police party arrived.

(a) took shelter in a thick jungle

(b) open indiscriminate fire

(c) took to flight

(d) unconditionally surrendered

Sol. (c) The chain snatchers took to flight when the police party arrived.

63. The given Statement is following by some courses of action. Assuming the Statement to be true, decide the correct option.

Statement There has been a significant drop in the water level in the lakes supplying water to the city.

Courses of Action

I. The water supply authority should impose a partial cut in supply to tackle the situation.

II. The Government should appeal to all the residents through mass media for minimal use of water.

III. The Government should ban the water supply in lower areas.

(a) Statement I and II follow

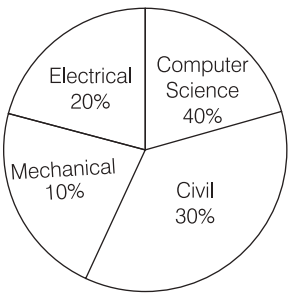
(b) Statement I and III follow

(c) Statement II and III follow

(d) All Statements follow

Sol. (a) Statement I and II follow.

64. The pie chart below has the breakup of the number of students, from different departments in an engineering college for the year 2012. The proportion of male to female students in each department is 5 : 4. There are 40 males in Electrical engineering. What is the difference between the numbers of female students in the Civil department and the female students in the Mechanical department?



Sol. In Civil Engineering female students $= \frac{4}{5} \times 30 = 24$

In Mechanical Engineering female students $= \frac{4}{5} \times 10 = 8$

Difference between Civil and Mechanical Engineering $= 24 - 8 = 16$

65. The probabilities that a student passes in Mathematics, Physics and Chemistry are M, P and C respectively. Of these subjects, the student has 75% chance of passing in atleast one, a 50% chance of passing in atleast two and a 40% chance of passing in exactly two. Following relations are drawn in M, P and C:

I. $P + M + C = 27/20$

II. $P + M + C = 13/20$

III. $P \times M \times C = 1/10$

(a) Only Relation I is true

(b) Only Relation II is true

(c) Relations II and III are true

(d) Relations I and III are true

Sol. (d) P(atleast two) – p(exact 2) $= 0.5 - 0.4 = 0.1$

$$0.75 = P + M + C + 0.1 - (0.5 + 0.11 \times 2)$$

$$\therefore \quad P + M + C = 0.65 + 0.7 = 1.35 = \frac{27}{20}$$