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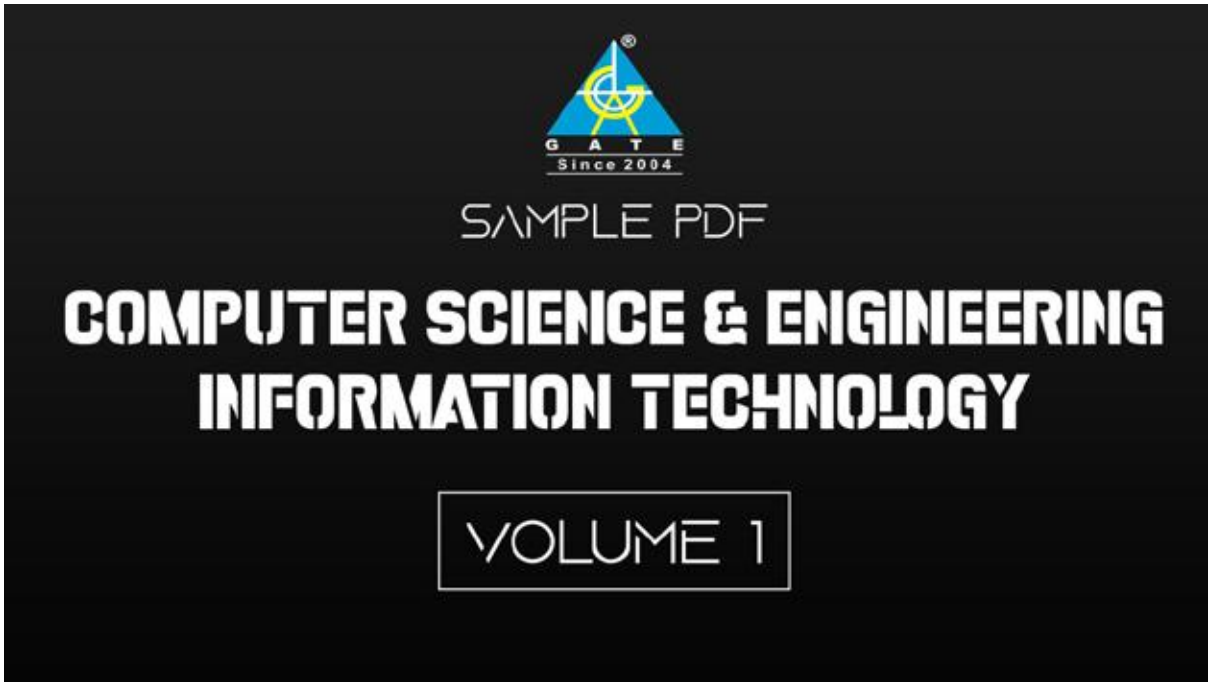

This sample PDF of **GATE Previous Years Solution Book** contains randomly selected questions with solutions from some of the chapters of every subject to let the aspirants have an idea about the content, style and appearance of the book.

Previous Years marks distribution analysis is also given in tabular form with index page of every subject, which contains analysis of GATE papers from 2003 onwards as GATE pattern has turned objective since 2003.

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GATE 2022

Computer Science & Information Technology

(Volume-I)

TOPIC WISE GATE SOLUTIONS

1987-2021

Team GATE ACADEMY

Topic wise GATE Solutions

Computer Science & Information Technology

Volume - I

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IMPORTANCE of GATE

GATE examination has been emerging as one of the most prestigious competitive exam for engineers. Earlier it was considered to be an exam just for eligibility for pursuing PG courses, but now GATE exam has gained a lot of attention of students as this exam open an ocean of possibilities like :

1. **Admission into IISc, IITs, IIITs, NITs**
   A good GATE score is helpful for getting admission into IISc, IITs, IIITs, NITs and many other renowned institutions for M.Tech./M.E./M.S. An M.Tech graduate has a number of career opportunities in research fields and education industries. Students get ₹ 12,400 per month as stipend during their course.
2. **Selection in various Public Sector Undertakings** (**PSUs**)
   A good GATE score is helpful for getting job in government-owned corporations termed as **Public Sector Undertakings** (**PSUs**) in India like IOCL, BHEL, NTPC, BARC, ONGC, PGCIL, DVC, HPCL, GAIL, SAIL & many more.
3. Direct recruitment to Group A level posts in Central government, i.e., Senior Field Officer (Tele), Senior Research Officer (Crypto) and Senior Research Officer (S&T) in Cabinet Secretariat, Government of India, is now being carried out on the basis of GATE score.
4. **Foreign universities through GATE**
   GATE has crossed the boundaries to become an international level test for entry into postgraduate engineering programmes in abroad. Some institutes in two countries **Singapore** and **Germany** are known to accept GATE score for admission to their PG engineering programmes.
5. **National Institute of Industrial Engg. (NITIE)**
   - NITIE offers **PGDIE / PGDMM / PGDPM** on the basis of GATE scores. The shortlisted candidates are then called for group Discussion and Personal Interview rounds.
   - NITIE offers a Doctoral Level Fellowship Programme recognized by Ministry of HRD (MHRD) as equivalent to PhD of any Indian University.
   - Regular full time candidates those who will qualify for the financial assistance will receive ₹ 25,000 during 1st and 2nd year of the Fellowship programme and ₹ 28,000 during 3rd, 4th and 5th year of the Fellowship programme as per MHRD guidelines.
6. **Ph.D. in IISc/ IITs**
   - IISc and IITs take admissions for Ph.D. on the basis of GATE score.
   - Earn a Ph.D. degree directly after Bachelor's degree through integrated programme.
   - A fulltime residential researcher (RR) programme.
7. **Fellowship Program in management (FPM)**
   - Enrolment through GATE score card
   - Stipend of ₹ 22,000 – 30,000 per month + HRA
   - It is a fellowship program
   - Application form is generally available in month of sept. and oct.

Note : In near future, hopefully GATE exam will become a mandatory exit test for all engineering students, so take this exam seriously. Best of LUCK !

GATE Exam Pattern

Section	Number of Questions	Marks Per Question	Total Marks
General Aptitude	5	1	5
	5	2	10
Technical + Engineering Mathematics	25	1	25
	30	2	60
Total Duration : 3 hours	**Total Questions : 65**		**Total Marks : 100**

Note :
(i) 40 to 45 marks will be allotted to Numerical Answer Type Questions.
(ii) MSQ also added from GATE 2021 for which **no negative** marking.

Pattern of Questions :

GATE 2021 would contain questions of THREE different types in all the papers :

(i) **Multiple Choice Questions (MCQ)** carrying 1 or 2 marks each, in all the papers and sections. These questions are objective in nature, and each will have choice of four answers, out of which ONLY ONE choice is correct.

Negative Marking for Wrong Answers : For a wrong answer chosen in a MCQ, there will be negative marking. For 1-mark MCQ, 1/3 mark will be deducted for a wrong answer. Likewise, for 2-mark MCQ, 2/3 mark will be deducted for a wrong answer.

(ii) **Multiple Select Questions (MSQ)** carrying 1 or 2 marks each in all the papers and sections. These questions are objective in nature, and each will have choice of four answers, out of which ONE or MORE than ONE choice(s) are correct.

Note : There is **NO negative** marking for a wrong answer in MSQ questions. However, there is NO partial credit for choosing partially correct combinations of choices or any single wrong choice.

(iii) **Numerical Answer Type (NAT)** Questions carrying 1 or 2 marks each in most of the papers and sections. For these questions, the answer is a signed real number, which needs to be entered by the candidate using the virtual numeric keypad on the monitor (keyboard of the computer will be disabled). No choices will be shown for these types of questions. The answer can be a number such as 10 or -10 (an integer only). The answer may be in decimals as well, for example, 10.1 (one decimal) or 10.01 (two decimals) or -10.001 (three decimals). These questions will be mentioned with, up to which decimal places, the candidates need to present the answer. Also, for some NAT type problems an appropriate range will be considered while evaluating these questions so that the candidate is not unduly penalized due to the usual round-off errors. Candidates are advised to do the rounding off at the end of the calculation (not in between steps). Wherever required and possible, it is better to give NAT answer up to a maximum of three decimal places.

Example : If the wire diameter of a compressive helical spring is increased by 2%, the change in spring stiffness (in %) is _ (correct to two decimal places).

Note : *There is NO negative marking for a wrong answer in NAT questions.*
Also, there is NO partial credit in NAT questions.

GATE SYLLABUS

Section 1 : Engineering Mathematics

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Monoids, Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions.

Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Calculus: Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration.

Probability and Statistics: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem.

Section 2 : Digital Logic

Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point).

Section 3 : Computer Organization and Architecture

Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

Section 4 : Programming and Data Structures

Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs.

Section 5 : Algorithms

Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph traversals, minimum spanning trees, shortest paths.

Section 6 : Theory of Computation

Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and contex-free languages, pumping lemma. Turing machines and undecidability.

Section 7 : Compiler Design

Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common subexpression elimination.

Section 8 : Operating System

System calls, processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU and I/O scheduling. Memory management and virtual memory. File systems.

Section 9 : Databases

ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

Section 10 : Computer Networks

Concept of layering: OSI and TCP/IP Protocol Stacks; Basics of packet, circuit and virtual circuit-switching; Data link layer: framing, error detection, Medium Access Control, Ethernet bridging; Routing protocols: shortest path, flooding, distance vector and link state routing; Fragmentation and IP addressing, IPv4, CIDR notation, Basics of IP support protocols (ARP, DHCP, ICMP), Network Address Translation (NAT); Transport layer: flow control and congestion control, UDP, TCP, sockets; Application layer protocols: DNS, SMTP, HTTP, FTP, Email.

General Aptitude (GA) :

Verbal Aptitude :

Basic English grammar: tenses, articles, adjectives, prepositions, conjunctions, verb-noun agreement, and other parts of speech Basic vocabulary: words, idioms, and phrases in context Reading and comprehension Narrative sequencing.

Quantitative Aptitude :

Data interpretation: data graphs (bar graphs, pie charts, and other graphs representing data), 2- and 3-dimensional plots, maps, and tables Numerical computation and estimation: ratios, percentages, powers, exponents and logarithms, permutations and combinations, and series Mensuration and geometry Elementary statistics and probability.

Analytical Aptitude :

Logic: deduction and induction Analogy, Numerical relations and reasoning.

Spatial Aptitude :

Transformation of shapes: translation, rotation, scaling, mirroring, assembling, and grouping Paper folding, cutting, and patterns in 2 and 3 dimensions.

PREFACE

It is our pleasure, that we insist on presenting **"GATE 2022 Computer Science & Information Technology (Volume - I)"** authored for Computer Science and Engineering to all of the aspirants and career seekers. The prime objective of this book is to respond to tremendous amount of ever growing demand for error free, flawless and succinct but conceptually empowered solutions to all the question over the period 1987 - 2021.

This book serves to the best supplement the texts for Computer Science Engineering but shall be useful to a larger extent for Information Technology & other National Level CS related Exams as well. Simultaneously having its salient feature the book comprises :

- Step by step solution to all questions.
- Complete analysis of questions, i.e. chapter wise as well as year wise.
- Detailed explanation of all the questions.
- Solutions are presented in simple and easily understandable language.
- It covers all GATE questions from 1987 to 2021 (35 years).

The authors do not sense any deficit in believing that this title will in many aspects, be different from the similar titles within the search of student.

We would like to express our sincere appreciation to **Mrs. Sakshi Dhande Ma'am** (Co-founder, GATE ACADEMY Group) for her constant support and constructive suggestions and comments in reviewing the script.

In particular, we wish to thank GATE ACADEMY expert team members for their hard work and consistency while designing the script.

The final manuscript has been prepared with utmost care. However, going a line that, there is always room for improvement in anything done, we would welcome and greatly appreciate the suggestions and corrections for further improvement.

Umesh Dhande

(Director, GATE ACADEMY Learning)

ACKNOWLEDGEMENT

Years of recurring effort went into the volume which is now ready to cover the aptitude of GATE aspirants.

We are glad of this opportunity to acknowledge the views and to express with all the weaknesses of mere words the gratitude that we must always feel for the generosity of them.

We now express our gracious gratitude to the persons who have contributed a lot in order to put forth this into device. They are to be mentioned here and they are Nutesh, Yogesh, Anand, Shama, Ankit and Faizan.

We would also like to express our gracious gratitude to the faculty members of GATE ACADEMY who has contributed a lot in order to put forth this into device. They are to be mentioned here and they are **Gurupal S. Chawla, Sateesh Kesharwani, Kavindra Krishna** and **Sachin Tanwar.**

Lastly, we take this opportunity to acknowledge the service of the total team of publication and everyone who collaborated in producing this work.

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GATE 2022
Volume - I

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Volume - I

- ☑ Diligent solution of GATE previous year questions (1987-2021)
- ☑ Multi method approach for a single problem to develop crystal clear concepts
- ☑ This book is also a value addition for PSUs/ISRO/DRDO/BARC/DMRC/ UGC- NET/State-AE Exams

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A DEDICATED TECH TEAM TO SOLVE TECH QUERIES AND HANDLE TECHNICAL ISSUES.

Marks Distribution of C Programming in Previous Year GATE Papers.

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2003	3	3	9
2004*	3	8	19
2005*	4	4	12
2006*	-	6	12
2007*	-	5	10
2008*	1	12	25
2009	1	-	1
2010	1	2	5
2011	1	2	5
2012	1	3	7
2013	1	1	3
2014 Set-1	1	2	5
2014 Set-2	1	2	5

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2014 Set-3	2	1	4
2015 Set-1	1	2	5
2015 Set-2	2	1	4
2015 Set-3	1	4	9
2016 Set-1	2	3	8
2016 Set-2	1	2	5
2017 Set-1	1	4	9
2017 Set-2	2	4	10
2018	2	2	6
2019	2	4	10
2020	1	2	5
2021 Set-1	-	2	4
2021 Set-2	2	2	6

*** CS and IT combined**

1 C Programming

2006 IIT Kharagpur

1. Which one of the choices given below would be printed when the following program is executed ?

```
#include <stdio.h>
struct test
{
      int i;
      char *c;
}
st[] = {5, "become", 4, "better", 6, "jungle", 8, "ancestor",
7, "brother"};
main ()
{
     struct test *p = st;
     p += 1;
     ++p -> c;
     printf("%s,", p++ -> c);
     printf("%c,", *++p -> c);
     printf("%d,", p[0].i);
     printf("%s n", p -> c);
}
```

(A) jungle, n, 8, ncestor
(B) etter, u, 6, ungle
(C) cetter, k, 6, jungle
(D) etter, u, 8, ncestor

2009 IIT Roorkee

2. Consider the program below :

```
#include <stdio.h>
int fun(int n,int *f_p)
{
```

```
        int t, f;
        if (n <= 1)
        {
              *f_p =1;
              return 1;
        }
        t = fun (n- 1, f_p);
        f = t + *f_p;
        *f_p = t;
        return f;
}
int main()
{
        int x = 15;
        printf ("%d\ n", fun(5,&x));
        return 0;
}
```

The value printed is :

(A) 6 (B) 8 (C) 14 (D) 15

2014 IIT Kharagpur

3. 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.

2015 IIT Kanpur

4. Consider the C program below.

```
#include < stdio.h >
int *A, stkTop;
int stkFunc(int opcode, int val)
{
        static int size=0, stkTop=0;
        switch (opcode)
```

```
        {
            case -1: size = val; break;
            case 0: if (stkTop < size) A[stkTop++] = val; break;
            default: if (stkTop) return A[--stkTop];
        }
        return -1;
}
int main()
{
        int B[20]; A = B; stkTop = -1;
        stkFunc (-1, 10);
        stkFunc ( 0, 5);
        stkFunc ( 0, 10);
        printf ("%d\n", stkFunc(1, 0) + stkFunc(1, 0));
}
```

The value printed by the above program is _____.

5. Consider the following C program.

```
# include <stdio.h>
int f1(void);
int f2(void);
int f3(void);
int x = 10;
int main()
{
        int x = 1;
            x += f1() + f2() + f3() + f2();
        printf("%d", x);
        return 0;
}
int f1()
{
        int x = 25;
            x++;
        return x;
}
int f2( )
{
        static int x = 50;
            x++;
        return x;
```

```
}
int f3( )
{
      x *= 10;
      return x;
}
```

The output of the program is _____.

2017 IIT Roorkee

6. Consider the following two functions

```
void fun1(int n)
{
      if(n == 0) return;
      printf("%d", n);
      fun2(n-2);
      printf("%d", n);
}
Void fun2(int n)
{
      if(n == 0) return;
      printf("%d", n);
      fun1(++n);
      printf("%d", n);
}
```

The output printed when fun1 (5) is called is

(A) 53423122233445 (B) 53423120112233

(C) 53423122132435 (D) 53423120213243

7. Consider the following snippet of a C program. Assume that swap (&x,&y) exchanges the content of x and y :

```
int main ()
{
      int array[] = {3, 5, 1, 4, 6, 2};
      int done =0;
      int i;
      while (done==0)
      {
            done =1;
            for (i=0; i<=4; i++)
            {
```

```
                    if (array[i] < array[i+1])
                    {
                        swap(&array[i], &array[i+1]);
                        done=0;
                    }
                }
                for (i=5; i>=1; i--)
                {
                    if (array[i] > array[i-1])
                    {
                        swap(&array[i], &array[i-1]);
                        done =0;
                    }
                }
            }
            printf("%d", array[3]);
        }
```

The output of the program is _____

2018 IIT Guwahati

8. Consider the following C code. Assume that unsigned long int type length is 64 bits.

```
unsigned long int fun(unsigned long int n)
{
    unsigned long int i, j = 0, sum = 0;
    for( i = n; i > 1; i = i/2) j++;
    for( ; j > 1; j = j/2) sum++;
    return sum;
}
```

The value returned when we call fun with the input 2^{40} is

(A) 4 (B) 5 (C) 6 (D) 40

2019 IIT Madras

9. Consider the following C program :

```
#include<stdio.h>
int r()
{
    static int num=7;
    return num--;
}
```

```
int main()
{
      for(r();r();r())
      printf("%d ",r());
      return 0;
}
```

Which one of the following values will be displayed on execution of the programs?

(A) 41 (B) 52 (C) 63 (D) 630

2020 IIT Delhi

10. Consider the following C functions.

```
int fun1(int n)
{
      static int i= 0;
      if (n > 0)
      {
            ++i;
            fun1(n-1);
      }
      return (i);
}
int fun2(int n)
{
      static int i= 0;
      if (n>0)
      {
            i = i+ fun1 (n);
            fun2(n-1) ;
      }
      return (i);
}
```

The return value of fun2(5) is _____ .

❖❖❖❖

Answers C Programming

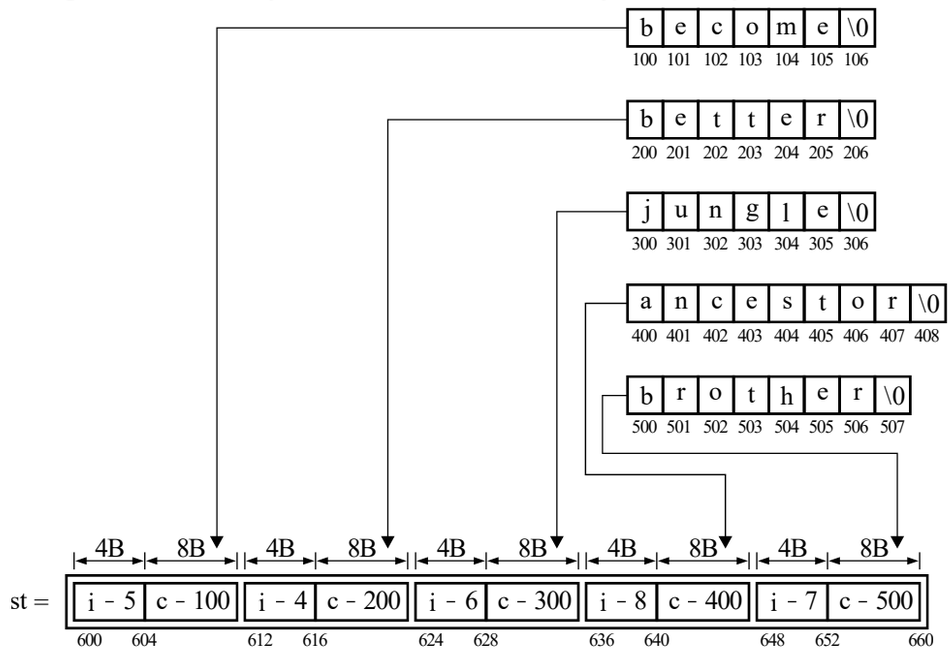
1	B	2	B	3	C	4	15	5	230
6	A	7	3	8	B	9	B	10	55

Explanations C Programming

1 (B)

Given:

For the given code snippet, we draw the following representation for the given array, considering int to be of 4 bytes and address of memory to be 8 bytes.



$\Rightarrow$ struct test *p = st

p holds the address of first structure element stored in st array.

i.e. 600 (p)

$\Rightarrow$ $p+=1 \Rightarrow p=p+1$

p hold address of next structure element.

i.e. 612 (p)

$\Rightarrow$ $++p \rightarrow c$ can be rewritten as $++(p \rightarrow c)$, therefore it will first retrieve the character pointer value from structure address 612 and increment character pointer, therefore "st" array's second element gets updated as

i - 4	c - 201
612	616 624

$\Rightarrow$ $(p++ \rightarrow c)$

This will again retrieve the character pointer from the address stored in p, and then later on increment p value.

Therefore, $(p++ \rightarrow c)$ return address 201 and then updates p to next structure address.

i.e. $\underset{p}{\boxed{624}}$

printf will print the string starting from address 201.

$\Rightarrow$ $(*++p \rightarrow c)$ can be written $(*++p \rightarrow c)$, therefore it will firstly retrieve character pointer value from given structure address (i.e. 300) than it will increment the character pointer value to 301. Therefore, 3rd element of array gets updated as

i - 6	c - 301
624	628 636

And at last it tries to get the value at given character address and prints it i.e. "u".

$\Rightarrow$ $p[0].i$ or $(*(p+0)).i$ will return int part of structure stored at p address. i.e. 6.

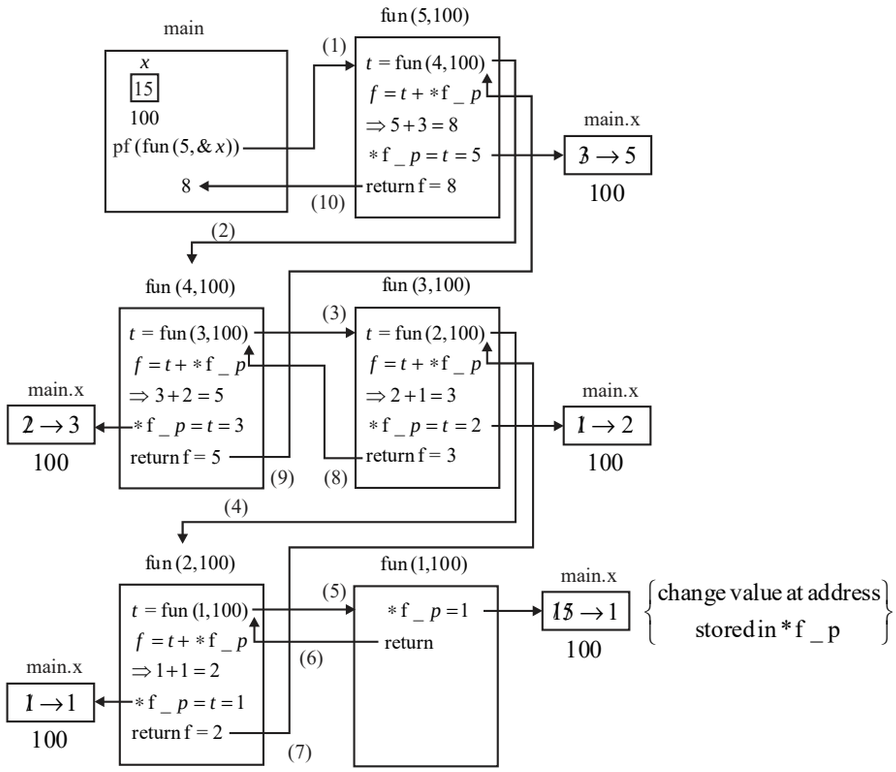
$\Rightarrow$ $(p \rightarrow c)$ will return character pointer value (address of string) of 3rd structure element starting from given address. i.e. "ungle".

Hence, the correct option is (B).

2 (B)

Given:

For the given code snippet, we draw the following representation for the function calling, where main.x refers to x variable in main function.



Hence, the correct option is (B).

3 (C)

Given:

For the given pseudocode, we can write the mathematical representation for the given loops as followed:

$$\Rightarrow \quad \sum_{i=1}^{n}\sum_{j=i}^{n}\sum_{k=j+1}^{n}1$$

$$\Rightarrow \quad \sum_{i=1}^{n}\sum_{j=i}^{n}(n-j)$$

$$\Rightarrow \quad \sum_{i=1}^{n}\sum_{j=i}^{n}n-\sum_{i=1}^{n}\sum_{j=i}^{n}j$$

$$\Rightarrow \quad n\sum_{i=1}^{n}\sum_{j=i}^{n}1-\sum_{i=1}^{n}\sum_{j=i}^{n}j$$

$$\Rightarrow \quad n\left(\sum_{i=1}^{n}(n-i+1)\right)-\sum_{i=1}^{n}\left(\frac{n(n+1)}{2}-\frac{i(i-1)}{2}\right)$$

$$\Rightarrow \quad n^3-\frac{n^2(n+1)}{2}+n^2-\frac{n^2(n+1)}{2}+\frac{1}{2}\sum_{i=1}^{n}i^2-\frac{1}{2}\sum_{i=1}^{n}i$$

$$\because \quad \sum i^2=\frac{n(n+1)(2n+1)}{6},\sum i=\frac{n(n+1)}{2}$$

$$\Rightarrow \quad n^3-n^2(n+1)+n^2+\frac{n(n+1)(2n+1)}{12}-\frac{n(n+1)}{4}$$

$$\Rightarrow \quad n^3-n^3-n^2+n^2+\frac{n(n+1)}{4}\left(\frac{2n+1}{3}-1\right)$$

$$\Rightarrow \quad \frac{n(n+1)(2n+1-3)}{12}$$

$$\Rightarrow \quad \frac{2(n-1)n(n+1)}{12}$$

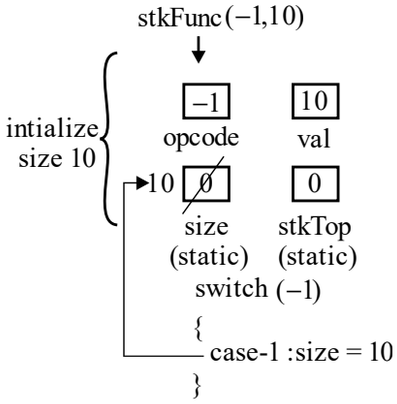
$$\Rightarrow \quad \frac{(n-1)n(n+1)}{6}$$

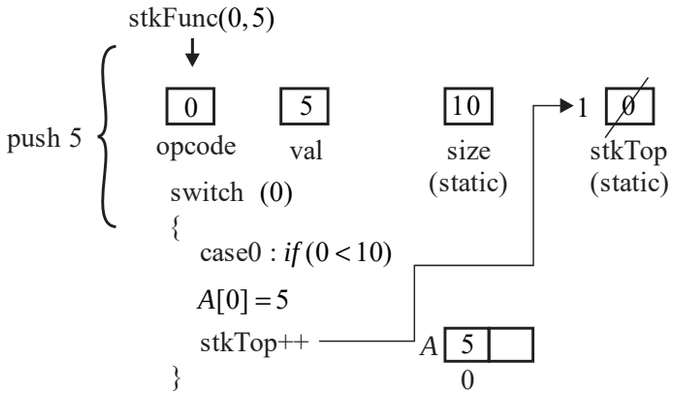
Hence, the correct option is (C).

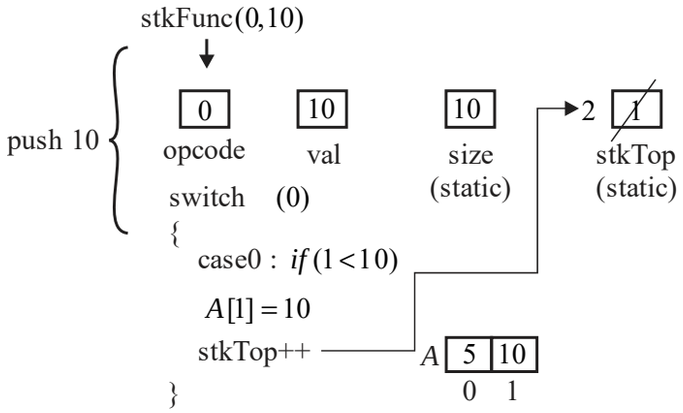
4. (15)

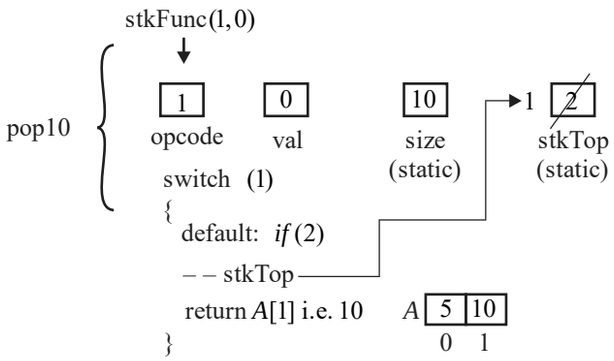
Given:

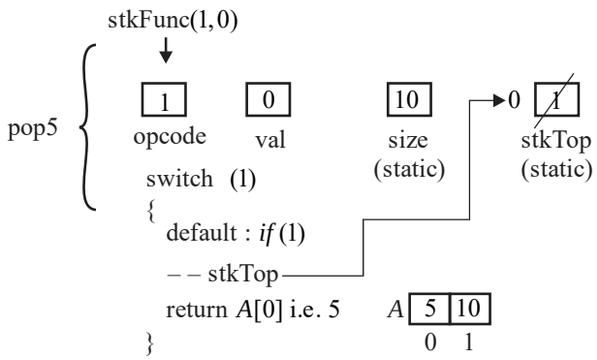
For the given code snippet, we draw the diagrammatical representation for the function calls, starting with initial condition, stkTop = –1











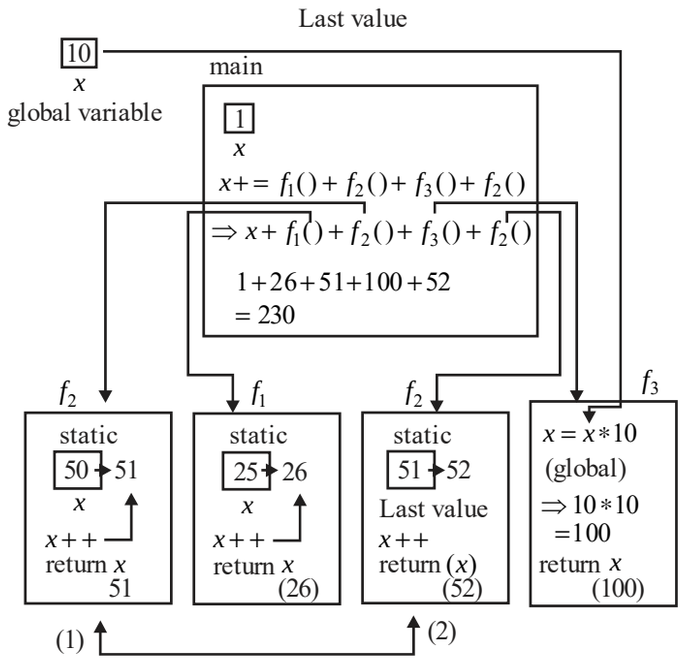
printf (10 + 5)

Hence, the correct answer is 15.

5 (230)

Given :

For the given code snippet, we draw the following representation for the function calling



Hence, the correct answer is 230.

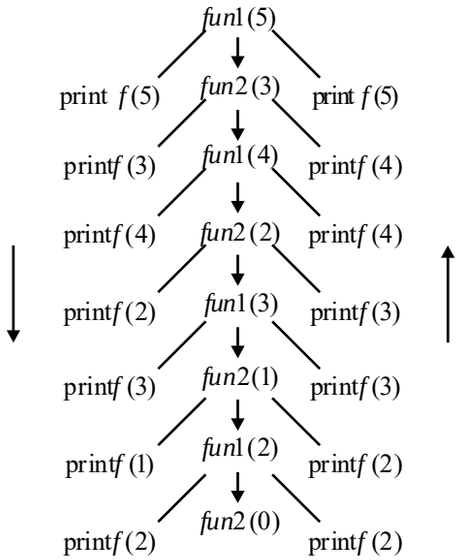
6 (A)

Note :

From fun1( ), fun2( ) gets called but it do not modifies value of n for the statements followed afterward in fun1( ). Whereas, from fun2( ) when fun1( ) gets called it first increments the value, therefore we get incremented value of n for the statements followed afterward in fun2 ( ).

Given:

For the given code snippet, we draw the following representation for the function calling



The output printed when fun1 (5) is 53423122233445

Hence, the correct option is (C).

7 (3)

Given: array[ ] = {3,5,1,4,6,2}

Note: if we observe carefully first for loop moves minimum value towards RHS & second for loop moves maximum towards right.

while loop's I[st] iteration (∵ done = 0)

done = 1

I[st] for loop's iterations

Counter	Array						
i	3	5	1	4	6	2	
0	5	3	1	4	6	2	done = 0
1	5	3	1	4	6	2	no change
2	5	3	4	1	6	2	done = 0
3	5	3	4	6	1	2	done = 0
4	5	3	4	6	2	1	done = 0

II[nd] for loop's iterations

Counter	Array						
i	5	3	4	6	2	1	
5	5	3	4	6	2	1	no change
4	5	3	4	6	2	1	no change
3	5	3	6	4	2	1	done = 0
2	5	6	3	4	2	1	done = 0
1	6	5	3	4	2	1	done = 0

while loop's II[nd] iteration (∵ done = 0)

done = 1

I[st] for loop's iterations

Counter	Array						
i	6	5	3	4	2	1	
0	6	5	3	4	2	1	no change
1	6	5	3	4	2	1	no change
2	6	5	4	3	2	1	done = 0
3	6	5	4	3	2	1	no change
4	6	5	4	3	2	1	no change

II[nd] for loop's iterations

As the array is sorted now so it will not change/swap array element.

As last value of done = 0

Therefore, there will be again III[rd] iteration of while loop, but as it enters it modifies the variable done as done = 1 after which no for loop will change/swap array elements and hence last value of done remains to be 1

∴ When it wants to check while condition for 4[th] iteration to begin it fails, as done = 1

∴ final array = | 6 | 5 | 4 | 3 | 2 | 1 |

Array [3] $\Rightarrow 3$

Hence, the correct answer is 3.

8 (B)

Given $n = 2^{40}$

I[st] for loop works as followed:

i	2^{40}	2^{39}	2^{38}	----	2^{1}	2^{0}
j	1	2	3	----	40	Exit

∴ Last value of $j = 40$

II[nd] for loop works as followed:

j	40	20	10	5	2	1
Sum	1	2	3	4	5	Exit

Hence, the correct option is (B).

9 (B)

Given:

for $(r();r();r())$

General for loop (ex1; ex2; ex3)

→ ex1 : for initialization

→ ex2 : for condition checking, if it is true (if non 0 value), then body of for loop will be executed, if it is false (0) terminate the for loop.

→ ex3 : defines how for loop will iterate (modification i.e., increment, decrement, etc.)

```
for  (r();        r();        r())
      ↓           ↓           ↓
initialization  condition   modification
                checking
        {
              print (" % d",  r ( ));
        }
```

In each call r ( ), value of num () will return and decrement the value of num and saved to memory as num it is static variable.

Sequence of the call to function, r ( ) is as given below

$$\text{for}\left(\overset{1}{r()};\ \overset{2,5,8,11}{r()}\ ;\ \overset{4,7,10}{r()}\right)$$

$$\text{printf}\left(\%d, \overset{3,6,9}{r()}\right)$$

#call to r( )	Value returned by r( )
1	7
2	6
3	5
4	4
5	3
6	2
7	1
8	0
9	
10	

Check condition

Value printed

$\therefore$ Printed value or (5, 2)

Hence, the correct option is (B).

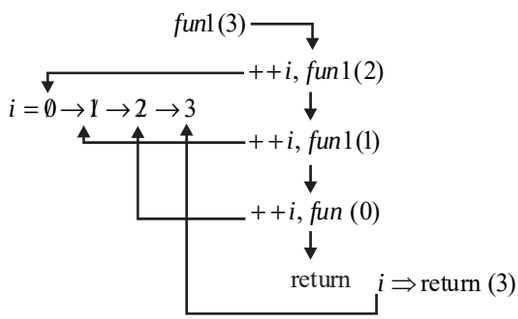
10 (55)

Given: we need to find fun2(5)

First, we need to get what fun1(n) does, it returns '$i+n$', where 'n' is input given and 'i' is the initial value during function call.

$\because$ it is static variable therefore its value persists during function calls.

Ex: fun1(3) $\rightarrow$

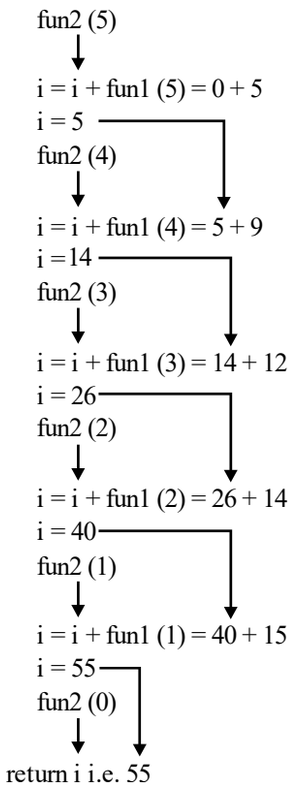


that is initial value of $i+n \Rightarrow 0+3=3$

As we know repetitive calls to fun1( ) will be made for the *n* values 5, 4, 3, 2 and 1, so, lets summarize it before, through the table

-	Initial value	Final value
n in fun1(n)	***i***	***i***
5	0	5
4	5	9
3	9	12
2	12	14
1	14	15

Now, the fun2 ( ) function working is given below using fun1 ( ) return values mentioned in table given before.



So final value return fun2 (5) is 55

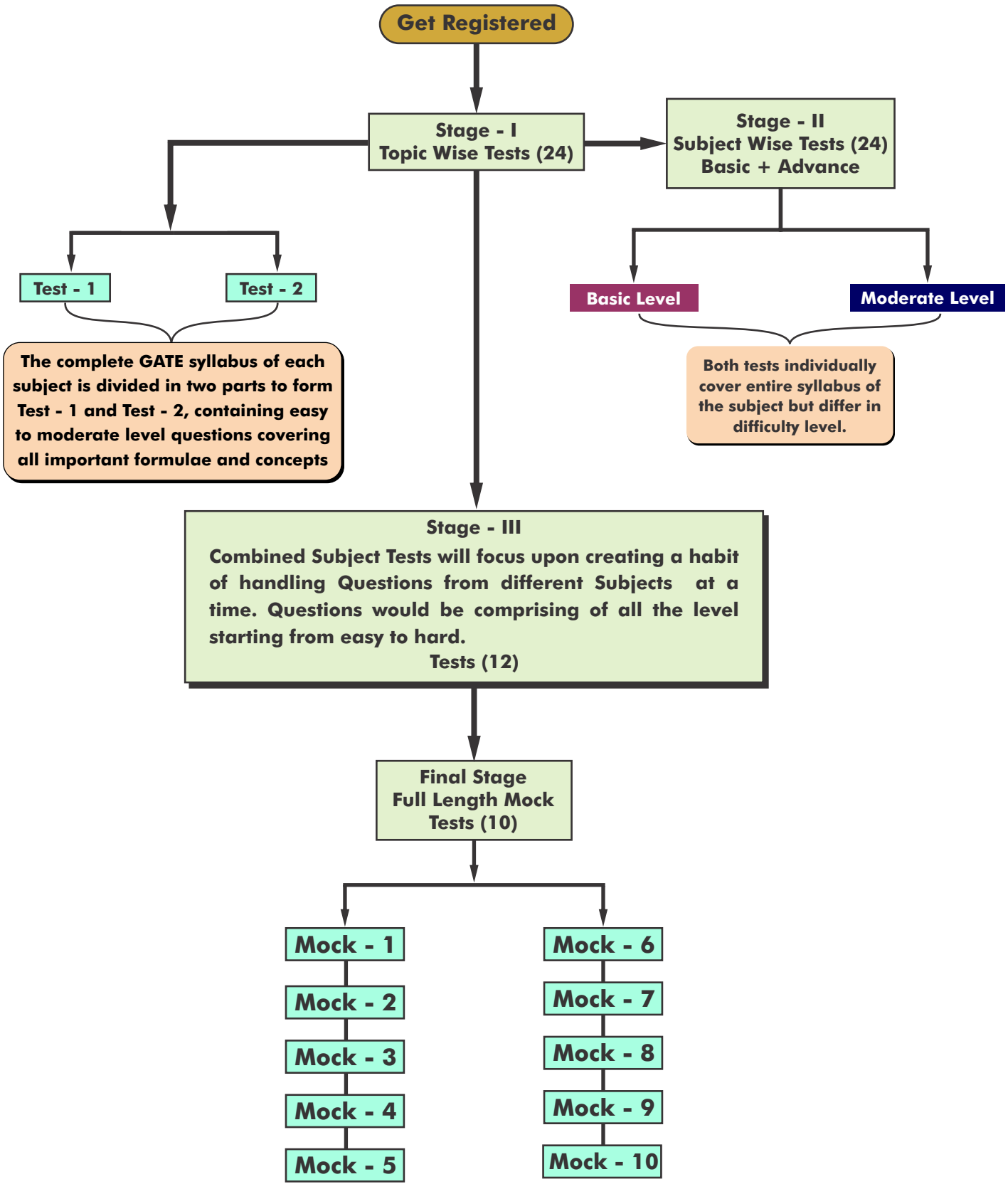
Hence, the correct answer is (55).

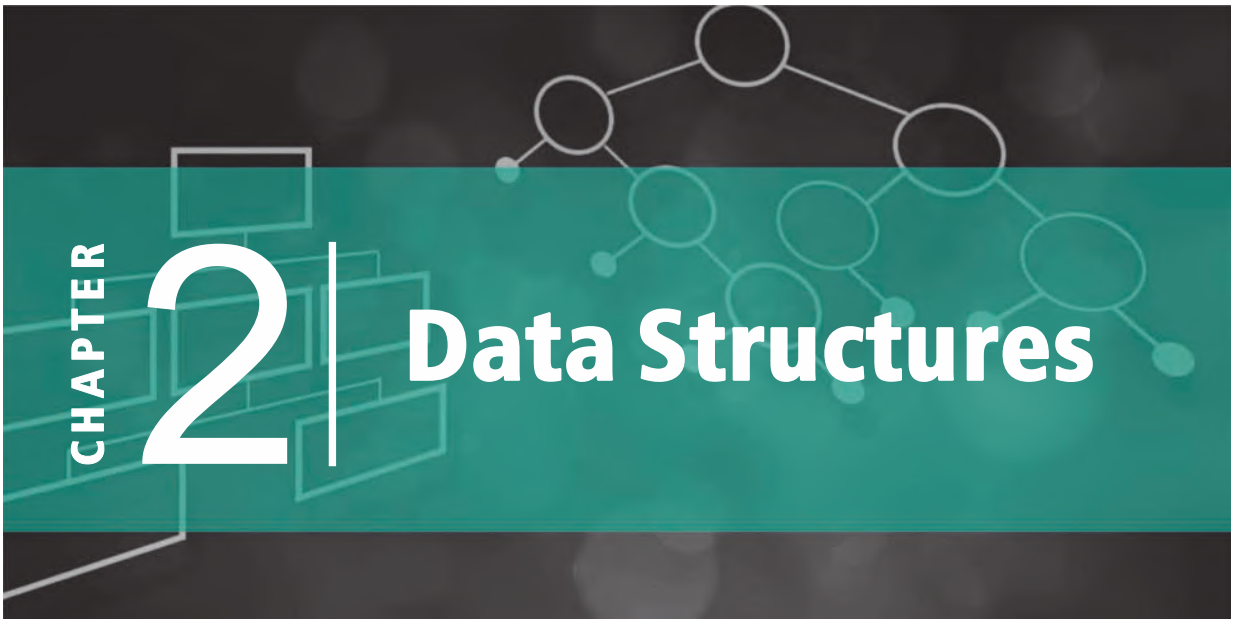
❖❖❖❖

GATE ACADEMY

TEST SERIES STRUCTURE (CS-IT)

(One Year Program)





Marks Distribution of Data Structures in Previous Year GATE Papers.

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2003	2	7	16
2004*	6	7	20
2005*	6	10	26
2006*	4	4	12
2007*	2	11	24
2008*	1	13	27
2009	-	4	8
2010	1	2	5
2011	1	2	5
2012	-	1	2
2013	-	4	8
2014 Set-1	1	1	3
2014 Set-2	2	1	4
2014 Set-3	1	2	5

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2015 Set-1	2	2	6
2015 Set-2	1	3	7
2015 Set-3	3	3	9
2016 Set-1	1	2	5
2016 Set-2	2	3	8
2017 Set-1	2	1	4
2017 Set-2	1	1	3
2018	2	2	6
2019	-	1	2
2020	2	1	4
2021 Set-1	2	3	8
2021 Set-2	1	1	3

*** CS and IT combined**

Syllabus : Data Structures

Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs.

Contents : Data Structures

2 Data Structure

1998 IIT Delhi

1. Compute the postfix equivalent of the following expression :

$$3 * \log(x+1) - \frac{a}{2}$$

2003 IIT Madras

2. Let G = (V, E) be an undirected graph with a subgraph $G_1 = (V_1, E_1)$. Weights are assigned to edges of G as follows :

$$w(e) = \begin{cases} 0 \text{ if } e \in E_1 \\ 1 \text{ otherwise} \end{cases}$$

A single-source shortest path algorithm is executed on the weighted graph (V, E, w) with an arbitrary vertex v_1 of V_1 as the source. Which of the following can always be inferred from the path costs computed?

(A) The number of edge in the shortest paths from v_1 to all vertices of G.

(B) G_1 is connected

(C) V_1 from a clique in G

(D) G_1 is a tree

2015 IIT Kanpur

3. A young tableau is a 2D array of integers increasing from left to right and from top to bottom, any unfilled entries are marked with ∞, and hence there cannot be any entry to the right of, or below a ∞. The following young tableau consists of unique entries.

1	2	5	14
3	4	6	23
10	12	18	25
31	∞	∞	∞

When an element is removed from a young tableau, other elements should be moved into its place so that the resulting table is still a young tableau (unfilled entries may be filled in with a ∞). The minimum number of entries (other than 1) to be shifted, to remove 1 from the given young tableau is _____.

4. Which one of the following hash function on integers will distribute keys most uniformly over 10 buckets numbered 0 to 9 i ranging from 0 to 2020?

(A) $h(i) = i^2 \bmod 10$

(B) $h(i) = i^3 \bmod 10$

(C) $h(i) = (11 * i^2) \bmod 10$

(D) $h(i) = (12 * i) \bmod 10$

5. Consider the following array of elements

$\langle 89, 19, 50, 17, 12, 15, 2, 5, 7, 11, 6, 9, 100 \rangle$.

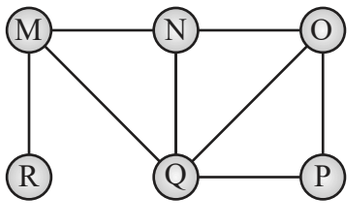
The minimum number of interchanges needed to convert it into a max-heap is

(A) 4 (B) 5

(C) 2 (D) 3

2017 IIT Roorkee

6. The Breadth First Search (BFS) algorithm has been implemented using the queue data structure. Which one of the following is a possible order of visiting the nodes in the graph below?



(A) MNOPQR (B) NQMPOR

(C) QMNROP (D) POQNMR

2020 IIT Delhi

7. Consider a double hashing scheme in which the primary hash function is $h_1(k) = k \bmod 23$, and the secondary hash function is $h_2(k) = 1+(k \bmod 19)$. Assume that the table size is 23. Then the address returned by probe 1 in the probe sequence (assume that the probe sequence begins at probe 0) for key value k = 90 is _____ .

2021 IIT Bombay

8. Consider the following statements.

S_1 : The sequence of procedure calls corresponds to a pre-order traversal of the activation tree.

S_2 : The sequence of procedure returns corresponds to a post-order traversal of the activation tree.

Which one of the following options is correct?

(A) S_1 is true and S_2 is true

(B) S_1 is true and S_2 is false

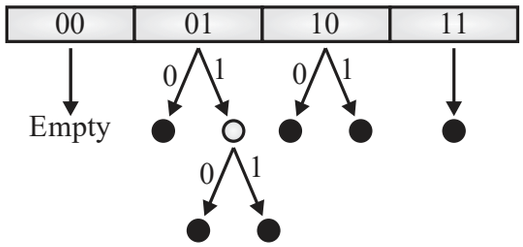
(C) S_1 is false and S_2 is true

(D) S_1 is false and S_2 is false

9. Consider a dynamic hashing approach for 4 big integer keys.

1. The main hash table size is 4.
2. The 2 least significant bits of a key is used to index into the main hash table
3. Initially, the main hash table entries are empty
4. Thereafter, when more keys are hashed into it to resolve collisions, the set of all keys corresponding to a main hash table entry is organized as a binary tree that grows on demand.
5. First the 3rd least significant bit is used to divide the keys into left and right subtrees.
6. To resolve more collisions, each node of the binary tree is further sub-divided into left and right subtrees based on the 4th least significant bit.
7. A split is done only if it is needed i.e. only when there is a collision.

Consider the following state of the hash table.



Which of the following sequence of key insertions can cause the above state of the hash table (assume the key are in decimal notation)

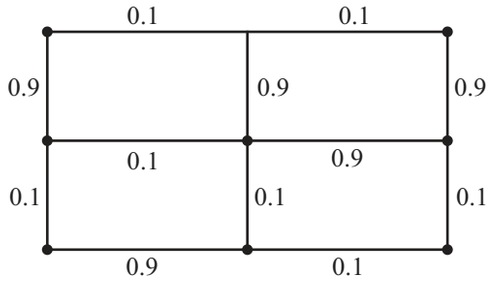
(A) 9, 5, 10, 6, 7, 1

(B) 10, 9, 6, 7, 5, 13

(C) 9, 5, 13, 6, 10, 14

(D) 5, 9, 4, 13, 10, 7

10. Consider the following undirected graph with edge weights as shown:



The number of minimum-weight spanning trees of the graph is _____.

Answers Data Structure

1	*	2	B	3	5	4	B	5	D
6	D	7	13	8	A	9	B	10	3

Explanations Data Structure

1 (*)

Given : expression $3*\log(x+1)-a/2$

Conversion to an equivalent postfix expression.

Associativity	Symbol	Precedence	
$L \to R$	+, −	1	↓ high
$L \to R$	/, *	2	
$R \to L$	↓	3	
$R \to L$	Unary (log)	4	

Note : parenthesis evaluated first then operator step by step conversion.

$= ((3*(\log(x+1)))-(a/2))$

$= ((3*(\log(x1+)))-(a2/))$

$= ((3*(x1+\log))-(a2/))$

$= ((3x1+\log*))-(a2/))$

$= 3x1+\log*a2/-$

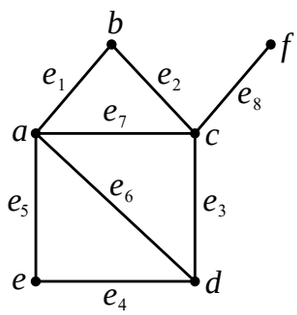
Hence, the correct answer is $= 3x1+\log*a2/-$

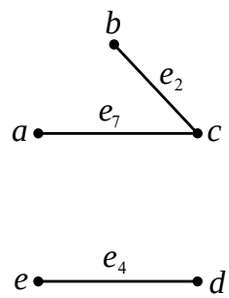
2 (B)

Given :

G = (V, E) be an undirected graph with a subgraph $G_1 = (V_1, E_1)$.

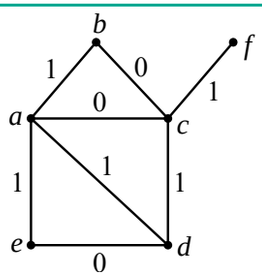
Weight of edge e = $w(e) = \begin{cases} 0 \text{ if } e \in E_1 \\ 1 \text{ otherwise} \end{cases}$



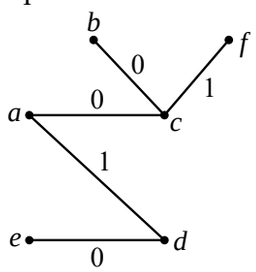


$$W(e) = \begin{cases} 0 & \text{if } e \in E_1 \\ 1 & \text{otherwise} \end{cases}$$

Assign weight to G.



Apply shortest path cost



Subgraph contains a, b, c, d, e vertices if a and d are connected in G_1, then cost from a to d in G will be 0, but it is 1. Hence G_1 is not connected.

Hence, the correct option is (B).

3 5

Given :

Initial Young tableau all unique entries:

1	2	5	14
3	4	6	23
10	12	18	25
31	∞	∞	∞

As per the given point in the question, if the element removed from young tableau it should be young tableau which is increasing from left to right & top to bottom.

So, when 1 is removed, smallest adjacent element should take place in such manner that there is an increasing order from left to right & top to bottom.

2 ← (2)		5	14
3	4	6	23
10	12	18	25
31	∞	∞	∞

So, 2 replaced 1

Now when 2 is moved to 1, it should be replaced by smallest adjacent which is 4.

2	4 ↑	5	14
3	(4)	6	23
10	12	18	25
31	∞	∞	∞

When 4 is moved to 2, it should be replaced by its smallest adjacent which is 6.

2	4	5	14
3	6 ← (6)		23
10	12	18	25
31	∞	∞	∞

When 6 is moved to 4, it should be replaced by its smallest adjacent which is 18.

2	4	5	14
3	6	18 ↑	23
10	12	(18)	25
31	∞	∞	∞

When 18 is moved to 6, it should be replaced by its smallest adjacent which is 25.

2	4	5	14
3	6	18	23
10	12	25 ← (25)	
31	∞	∞	∞

When 25 is moved to 18, it should be replaced by it smallest adjacent which is ∞.

2	4	5	14
3	6	18	23
10	12	25	∞
31	∞	∞	∞

So total number shifted are 2, 4, 6, 18 and 25 is (5).

Hence, the correct answer is 5.

4 (B)

Given : Length of hash table = 10

Key = 1, 2, 3, … ,9

If you do cube all number from 0 to 9, you get following.

Number	Cube	Last digit in cube
0	0	0
1	1	1
2	8	8
3	27	7
4	64	4
5	125	5
6	216	6
7	343	3
8	512	2
9	729	9

Therefore, all numbers from 0 to 9 are equally divided in 10 buckets. If we take for square we don't get equal distribution. In the following table 1, 4, 6 and 9 repeated so these buckets would have more entries and buckets 2, 3, 7 and 8 would be empty.

Hence, the correct option is (B).

Key Point

The last digit of cube of 0 to 9 numbers are unique. Hence, i^3 mod 10 will result in 10 different value.

5 (D)

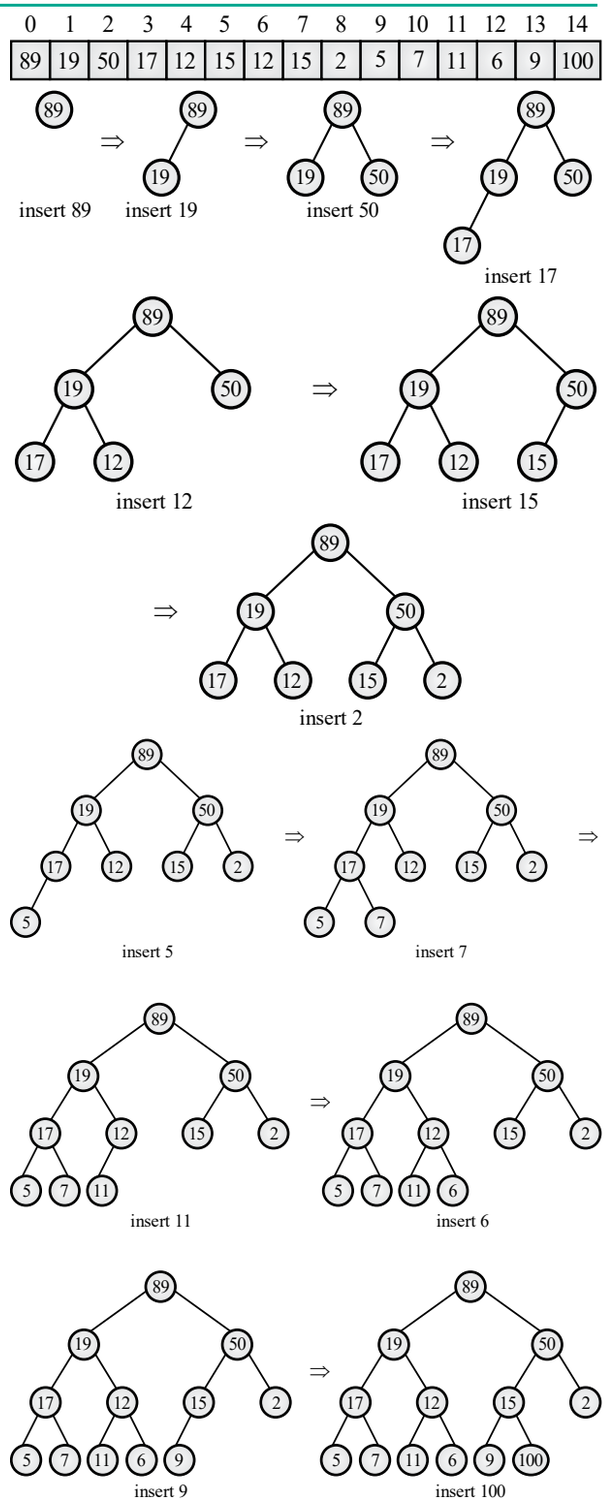
Given :

array of elements

$$\langle 89,\ 19,\ 50,\ 17,\ 12,\ 15,\ 2,\ 5,\ 7,\ 11,\ 6,\ 9,\ 100 \rangle$$

Key Point

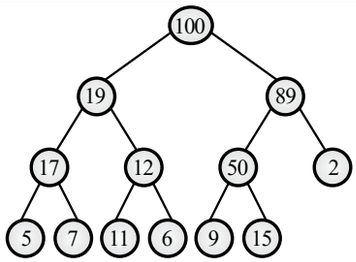
In max-heap root element is maximum comparing to its children.



Here we need to build a max heap, since 100 is greater value than 15, 50 and 89.

So, we need to inter change them.

Resultant tree is

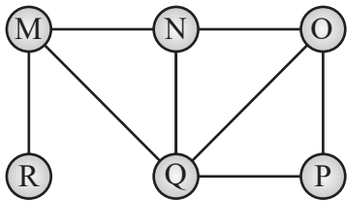


Therefore, we need 3 inter change value.

Hence, the correct option is (D).

6 (D)

Given :



Key Point

BFS : Start at root (Some arbitrary node of a graph sometime referred to as "search key") and explore the neighbor node first, before moving to the next level neighbor.

(A) MNOPQR

Adjacency list

M →	MQR	| M |
N →	MOQ	| M | N | Q | R |
Q →		

We cannot visit in this order as O is not an adjacent to N.

(B) NQMPOR

Adjacency list

N →	QMO	| N |
Q →	MNPO	| N | Q | M | O |
M →	NQR	| N | Q | M | O | P |

It is not possible to visit P before O as P is not adjacent to M.

(C)

Adjacency list

Q →	MNOP	| Q |
M →	NQR	| Q | M | N | O | P |
N →	MOQ	| Q | M | N | O | P | R |

It is not possible to visit R, as O is adjacent to N.

(D)

Adjacency list

P →	OQ	| P |
O →	NQ	| P | O | Q |
Q →	MNO	| P | O | Q | N |
N →	MOQ	| P | O | Q | N | M |
M →	MQR	| P | O | Q | N | M | R |
R →		

It is true

Hence, the correct option is (D).

7 13

Given : hash function $= h_1(k) = k \bmod 23$,

$h_2(k) = 1 + (k \bmod 19)$

Table size = 23

Key, $k = 90$,

Probe $i = 1$

- $h_1(k) = 90 \bmod 23 = 21$
- $h_2(k) = 1 + (90 \bmod 19) = 1 + 14 = 15$

According to double hashing formula

$(h_1(k) + i \times h_2(k)) \bmod (\text{table size})$

$= (21 + 1 \times 15) \bmod (23)$

$= 36 \bmod 23 = 13$

Hence, the correct answer is 13.

8 (A)

Given : Statements :

S1 : The sequence of procedure calls corresponds to a pre-order traversal of the activation tree.

S2 : The sequence of procedure returns corresponds to a post-order traversal of the activation tree.

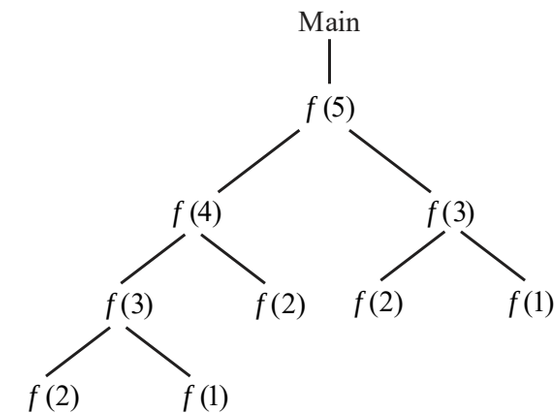
Consider the function calls that result from a main program calling *f*(5)

```
//Fibonacci Series using
Recursion
#include<stdio.h>
int fib(int n)
```

```
{
   if (n <= 1)
      return n;
   return fib(n-1) + fib(n-2);
}

int main ()
{
   fib(5)
   return 0;
}
```

Activation tree:



The sequence of procedure call is:

```
System starts main
      enter f(5)
          enter f(4)
              enter f(3)
                  enter f(2)
                  exit f(2)
                  enter f(1)
                  exit f(1)
              exit f(3)
              enter f(2)
              exit f(2)
          exit f(4)
          enter f(3)
              enter f(2)
              exit f(2)
              enter f(1)
              exit f(1)
                  exit f(3)
      exit f(5)
main ends
```

Pre-order traversal:

```
f(5),f(4),f(3),f(2),f(1),f(
2),f(3),f(2),f(1)
```

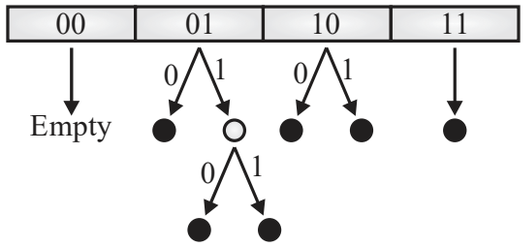
Post-order traversal:

```
f(2),f(1),f(3),f(2),f(4),f(
2),f(1),f(3),f(5)
```

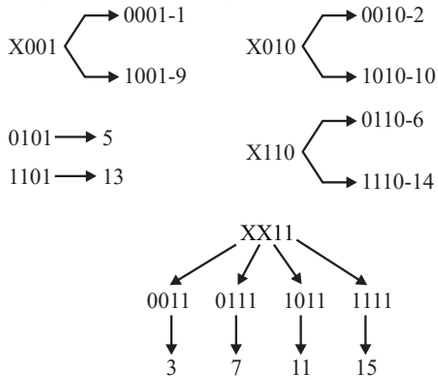
Hence, the correct option is (A).

9 (B)

Given : state of main hash table :



Following numbers are possible

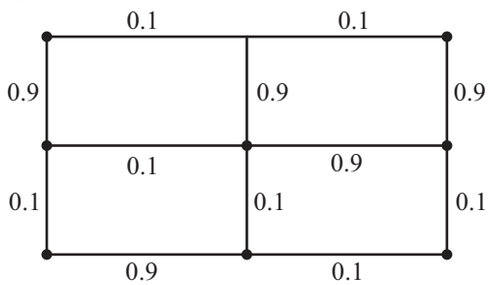


Among above possible values only one 4-bit combination should be present.

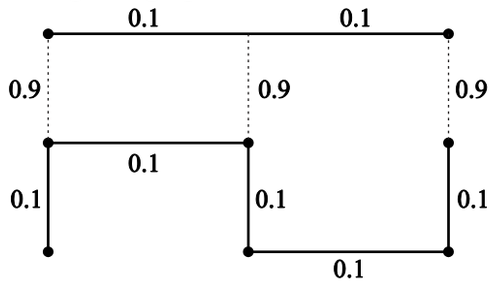
Hence, the correct option is (B).

10 3

Given:



MST for given graph is



Solid lines represent compulsory edges in MST and dotted lines represent optional edges in MST only one edge out of those 3 edges is possible hence answer is 3.

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Marks Distribution of Algorithms in Previous Year GATE Papers.

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2003	4	6	16
2004*	4	10	24
2005*	4	8	20
2006*	10	7	24
2007*	4	10	24
2008*	4	11	26
2009	2	5	12
2010	1	3	7
2011	2	3	8
2012	3	3	9
2013	1	3	7
2014 Set-1	2	2	6
2014 Set-2	2	2	6
2014 Set-3	1	2	5

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2015 Set-1	2	3	8
2015 Set-2	2	3	8
2015 Set-3	2	3	8
2016 Set-1	3	3	9
2016 Set-2	2	3	8
2017 Set-1	2	2	6
2017 Set-2	1	2	5
2018	2	3	8
2019	1	3	7
2020	2	2	6
2021 Set-1	4	4	12
2021 Set-2	3	3	9

*** CS and IT combined**

Syllabus : Algorithms

Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph traversals, minimum spanning trees, shortest paths.

Contents : Algorithms

3 Algorithms

2002 IISc Bangalore

1. Consider the following algorithm for searching for a given number x in an unsorted array $A[1.....n]$ having n distinct values :

1. Choose an i uniformly at random from 1….n;
2. If $A[i] = x$ then stop else goto 1;

Assuming that x is present on A, what is the expected number of comparisons made by the algorithm before it terminates?

(A) n (B) $n-1$

(C) $2n$ (D) $n/2$

2005 IIT Bombay

Common Data for Questions 2 and 3

We are given 9 tasks T_1, T_2.... T_9. The execution of each task requires one unit of time. We can execute one task at a time. Each task T_i has a profit P_i and a deadline di Profit P_i is earned if the task is completed before the end of the d_1^{th} unit of time.

Task	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Profit	15	20	30	18	18	10	23	16	25
Deadline	7	2	5	3	4	5	2	7	3

2. Are all tasks completed in the schedule that gives maximum profit?

(A) All tasks are completed

(B) T1 and T6 are left out

(C) T1 and T8 are left out

(D) T4 and T6 are left out

3. What is the maximum profit earned?

(A) 147 (B) 165

(C) 167 (D) 175

2006 IIT Kharagpur

4. A scheme for storing binary trees in an array X is as follows. Indexing of X starts at 1 instead of 0. the root is stored at X[1]. For a node stored at X[i], the left child, if any, is stored in X[2i] and the right child, if any, in X[2i+1]. To be able to store any binary tree on n vertices the minimum size of X should be.

(A) $\log_2 n$ (B) n

(C) $2n + 1$ (D) $2^n - 1$

2008 IISc Bangalore

5. A B-tree of order 4 is built from scratch by 10 successive insertions. What is the maximum number of node splitting operations that may take place?

(A) 3 (B) 4

(C) 5 (D) 6

2010 IIT Guwahati

6. Consider a complete undirected graph with vertex set {0, 1, 2, 3, 4}. Entry $W_{(i,j)}$ in the matrix W below is the weight of the edge {i, j}.

$$W = \begin{bmatrix} 0 & 1 & 8 & 1 & 4 \\ 1 & 0 & 12 & 4 & 9 \\ 8 & 12 & 0 & 7 & 3 \\ 1 & 4 & 7 & 0 & 2 \\ 4 & 9 & 3 & 2 & 0 \end{bmatrix}$$

What is the minimum possible weight of a spanning tree T in this graph such that vertex 0 is a leaf node in the tree T?

(A) 7 (B) 8

(C) 9 (D) 10

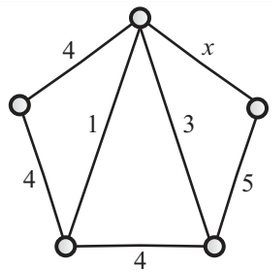
2014 IIT Kharagpur

7. 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 _____.

2018 IIT Guwahati

8. The number of possible min-heaps containing each value from {1, 2, 3, 4, 5, 6, 7} exactly once is _____.

9. Consider the following undirected graph G :



Choose a value for x that will maximize the number of minimum weight spanning trees (MWSTs) of G. The number of MWSTs of G for this value of x is _____.

2021 IIT Bombay

10. Consider the following recurrence relation

$$T(n) = \begin{cases} T(n/2) + T(2n/5) + 7n & \text{if } n > 0 \\ 1 & \text{if } n = 0 \end{cases}$$

Which one of the following options is correct?

(A) $T(n) = \theta(n)$

(B) $T(n) = \theta((\log n)^{5/2})$

(C) $T(n) = \theta(n \log n)$

(D) $T(n) = \theta(n^{5/2})$

Answers Algorithms

1	A	2	D	3	A	4	D	5	C
6	D	7	358	8	80	9	4	10	A

Explanations Algorithms

1 (A)

Given :

algorithm for searching for a given number x in an unsorted array $A[1.....n]$ having n distinct values :

1. Choose an i uniformly at random from 1…n;
2. If $A[i] = x$ then stop else goto 1;

Index for the element to search is chosen randomly.

Note : Every time the index is chosen independently

Any index can be chosen every time till we get desired element.

If we get desired element in K^{th} comparison then probability of getting it in K^{th} comparison is given $P(K)$.

Comparison (K)	$P(K)$
1	$\frac{1}{n}$
2	$\frac{n-1}{n}\times\frac{1}{n}$
3	$\frac{n-1}{n}\times\frac{n-1}{n}\times\frac{1}{n}$
4	$\frac{n-1}{n}\times\frac{n-1}{n}\times\frac{n-1}{n}\times\frac{1}{n}$

Expected no. of comparisons

$$E(c)=\sum_{K=1}^{\infty} K * P(K)$$

$$=1\times\frac{1}{n}+\frac{2}{n}\times\frac{(n-1)}{n}+\frac{3}{n}\frac{(n-1)^2}{n^2}+\frac{4}{n}\times\frac{(n-1)^3}{n^3}+...$$

$$=\frac{1}{n}\left(1+2\left(\frac{n-1}{n}\right)+3\left(\frac{n-1}{n}\right)^2+4\left(\frac{n-1}{n}\right)^3+.....\right)$$

$$=\frac{1}{n}\left(1+2\left(1-\frac{1}{n}\right)+3\left(1-\frac{1}{n}\right)^2+4\left(1-\frac{1}{n}\right)^3+.....\right)$$

say $\left(1-\frac{1}{n}\right)=x$ as $n>1$

$\therefore \quad 1-\frac{1}{n}<1$

$$=\frac{1}{n}(1+2x+3x^2+4x^3+.....)$$

Key Point

$1+2x+3x^2+4x^3.....$ is an AGP

Whose sum $=\frac{1}{(1-x)^2}$

Which can be derived using generating function as well.

$$E(c)=\frac{1}{n}\left(\frac{1}{(1-x)^2}\right)$$

Putting value of x $=\frac{1}{n}\left(\frac{1}{\left(1-\left(1-\frac{1}{n}\right)\right)^2}\right)$

$$=\frac{1}{n}\left(\frac{1}{\left(1-1+\frac{1}{n}\right)^2}\right)=\frac{1}{n}\left(\frac{1}{\frac{1}{n^2}}\right)$$

$$=\frac{1}{n}\times n^2=n$$

Hence, the correct option is (A).

2 (D)

Given :

Task	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Profit	15	20	30	18	18	10	23	16	25
Deadline	7	2	5	3	4	5	2	7	3

Key Point

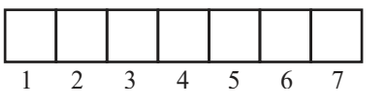
Steps to solve job sequencing with deadline

1. Arrange all jobs in decreasing order of profit.
2. Find maximum deadline and take array of that size.
3. Start from RHS of array, for every slot i apply linear search to find a job deadline $d_i \geq i$.
4. Add profit.

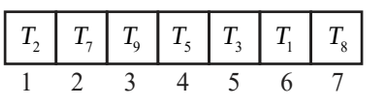
Step-1 : Sort all jobs in descending order of profit.

Task-	T_3	T_9	T_7	T_2	T_5	T_4	T_8	T_1	T_6
Profit-	30	25	23	20	18	18	16	15	10
Deadline-	5	3	2	2	4	3	7	7	2

Step-2 : Maximum deadline = 7, so take an array of size 7



Step-3 : Apply linear search to find job with deadline $d_i \geq i$



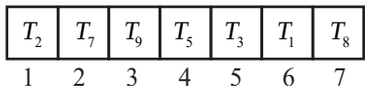
T_4 and T_6 are left out.

Hence, the correct option is (D).

3 (A)

Given :

Task	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Profit	15	20	30	18	18	10	23	16	25
Deadline	7	2	5	3	4	5	2	7	3



Add profits of all included task.

$$= 30 + 25 + 23 + 20 + 18 + 16 + 15$$

$$= 147$$

Hence, the correct option is (A).

4 (D)

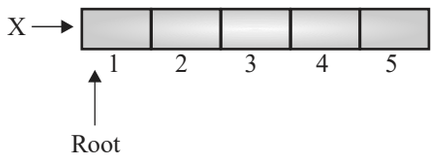
Given : A scheme for storing binary trees in an array X is as follows :

Indexing of X starts at 1 instead of 0.

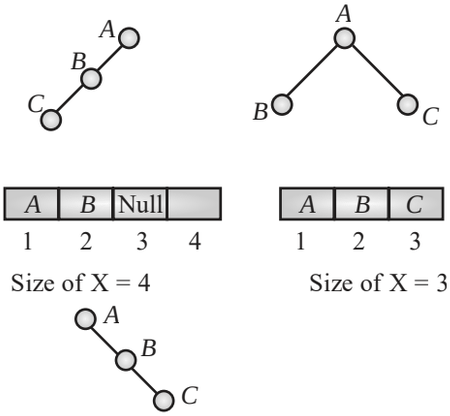
The root is stored at X[1].

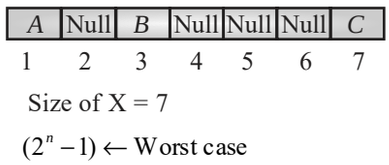
For a node stored at X[i], the left child, if any, is stored in X[2i] and the right child, if any, in X[2i+1].

Given array



Taking $n = 3$





$(2^n - 1) \leftarrow$ Worst case

Checking with various value of n, the worst case comes out $2^n - 1$.

Hence, the correct option is (D).

5 (C)

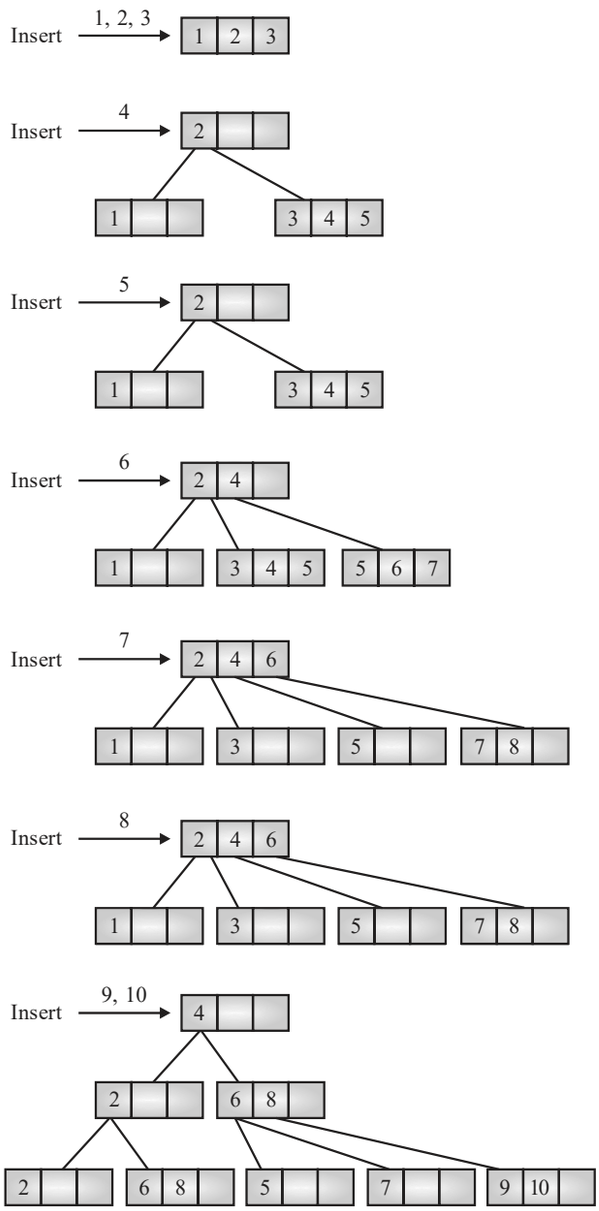
Given :

B-tree of order = 4

Number of child = $m = 4$

Number of key = $m - 1 = 4$

Let's take 10 successive key value (1, 2, 3 …. 10)



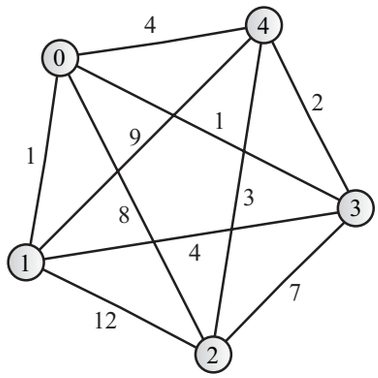
Hence, the correct option is (C).

6 (D)

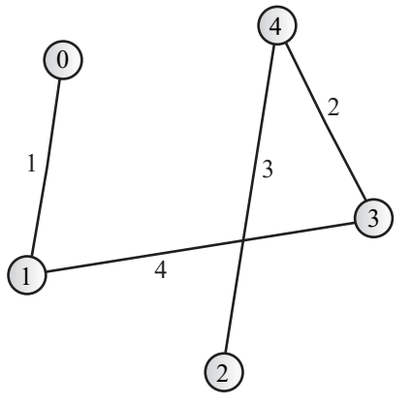
Given : A complete undirected graph with vertex set {0, 1, 2, 3, 4} weight of the edge {i, j} is as follows :

$$W = \begin{bmatrix} 0 & 1 & 8 & 1 & 4 \\ 1 & 0 & 12 & 4 & 9 \\ 8 & 12 & 0 & 7 & 3 \\ 1 & 4 & 7 & 0 & 2 \\ 4 & 9 & 3 & 2 & 0 \end{bmatrix}$$

Corresponding graph will be-



Minimum spanning tree with vertex 0 leaf node is



Total weight = 1 + 2 + 3 + 4 = 10

Hence, the correct option is (D).

7 358

Given : Length of sequence $P = 20$

Length of sequence $Q = 24$

Length of sequence $R = 30$

Length of sequence $S = 35$

Length of sequence $T = 50$

Key Point

Optimal merge pattern – arrange the sequence in ascending order merge two at a time and rearrange the sequence in ascending order repeat the procedure.

Note : In merge operation we do a comparison of two elements and put one element in the sorted output array. But for last element we want need any comparison, so for n output elements we need $(n-1)$ comparisons.

Merge P, Q and rearrange the sequence

R	S	(PQ)	T
30	35	44	50

Merge R, S and rearrange the sequence

PQ	T	RS
44	50	65

Merge PQ, T

RS	PQT
65	94

Merge PQT RS

$= 159$

So, total no. of comparisons

$= 43 + 64 + 93 + 158 = 358$

Hence, the correct answer is 358.

8 80

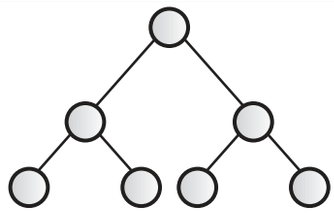
Given : Values : {1, 2, 3, 4, 5, 6, 7}

Key Point

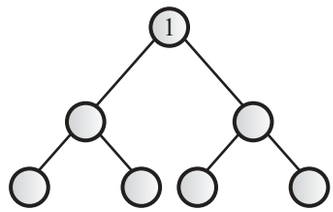
A min heap is a binary tree such that

- The data in each node is less than (or equal to) the data in that node's children.
- The binary tree is complete.

Since a min-heap is complete binary tree hence 7 nodes are distributed in 2 levels (root at level 0)

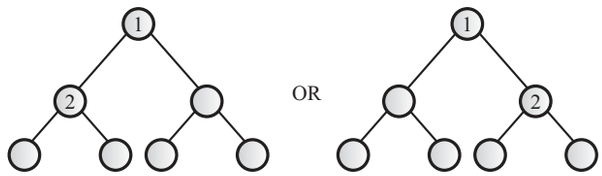


In min-heap smallest element is in root hence the structure is



In first level, second minimum element is present.

Hence, we have 2 choices for element 2.



Now for leaf node of element 2 we have 5 elements

So total no. of ways $= 5 \times 4 = 20$

Since leaf node can be arranged in 2 ways

We have $20 \times 2 = 40$ ways .

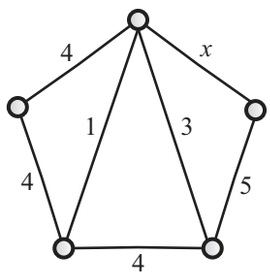
And finally left subtree of 1 i.e. root can be arranged in two ways hence total

$40 \times 2 = 80$ ways

Hence, the correct answer is 80.

9 4

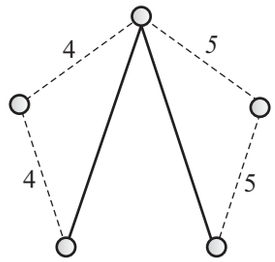
Given :



Key Point

Number of possible MST increases, when we have multiple edges with same edge weights.

If $x = 5$, then MST will be :



To maximize the number of MST, x should be 5.

So, number of MST $= 2 \times 2 = 4$

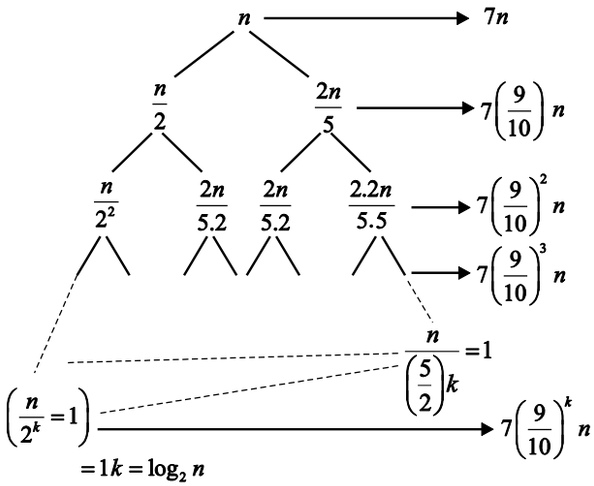
Hence, the correct answer is 4.

10 (A)

Given :

$$T(n) = \begin{cases} T(n/2) + T(2n/5) + 7n & \text{if } n > 0 \\ 1 & \text{if } n = 0 \end{cases}$$

Recurrence tree for given recurrence relation is



$$T(n) = 7n + 7\left(\frac{9}{10}\right)n + 7\left(\frac{9}{10}\right)^2 + \ldots + 7\left(\frac{9}{10}\right)^k n$$

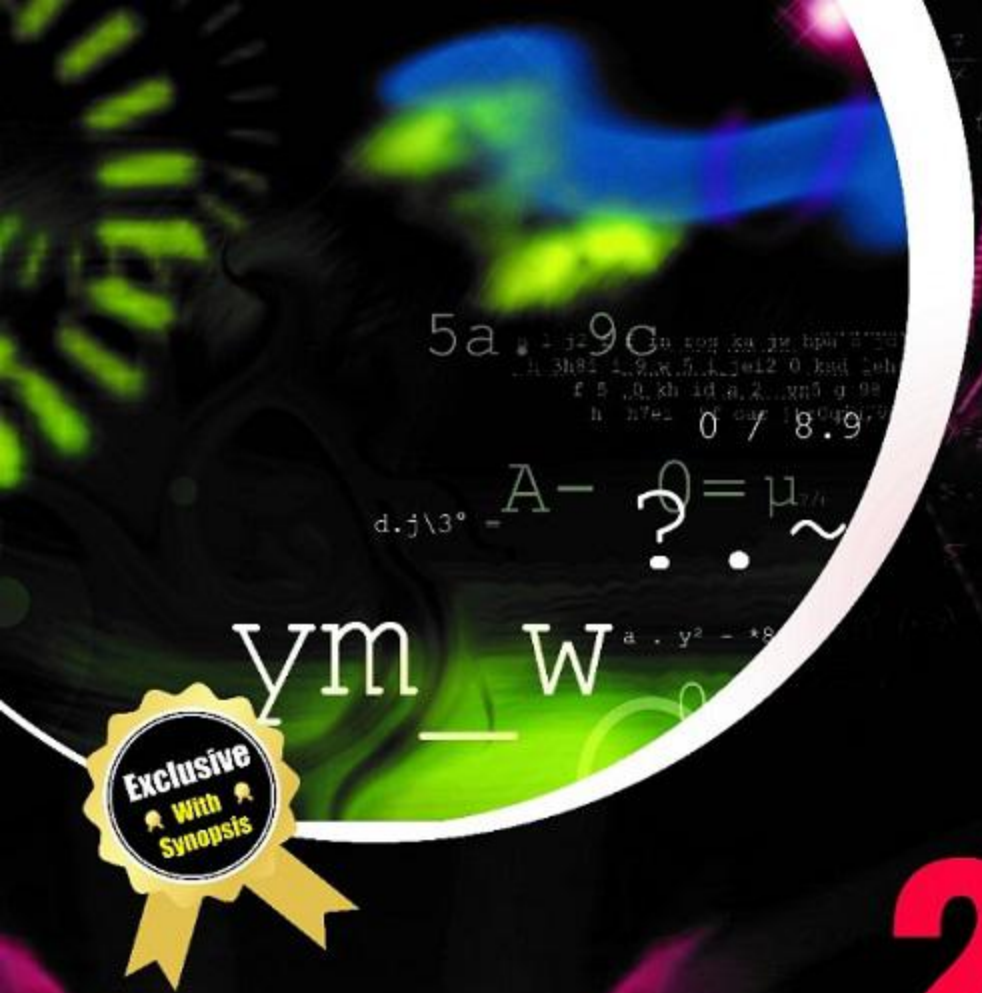
$$T(n) = 7n\underbrace{\left(1 + \left(\frac{9}{10}\right) + \left(\frac{9}{10}\right)^2 + \ldots + \left(\frac{9}{10}\right)^k\right)}_{\text{decreasing GP} \le \text{Constant}}$$

$$T(n) = 7n * O(1)$$

$$T(n) = O(n)$$

Hence, the correct option is (A).

❖❖❖❖



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Marks Distribution of Databases in Previous Year GATE Papers.

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2003	3	3	9
2004*	6	8	22
2005*	7	10	27
2006*	3	8	19
2007*	1	10	21
2008*	2	12	26
2009	-	5	10
2010	2	3	8
2011	2	2	6
2012	2	5	12
2013	1	3	7
2014 Set-1	2	3	8
2014 Set-2	2	3	8
2014 Set-3	2	3	8

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2015 Set-1	2	2	6
2015 Set-2	2	2	6
2015 Set-3	2	2	6
2016 Set-1	3	1	5
2016 Set-2	2	2	6
2017 Set-1	2	3	8
2017 Set-2	2	3	8
2018	2	2	6
2019	2	3	8
2020	2	3	8
2021 Set-1	2	3	8
2021 Set-2	1	4	9

*** CS and IT combined**

Syllabus : Databases

ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

Contents : Databases

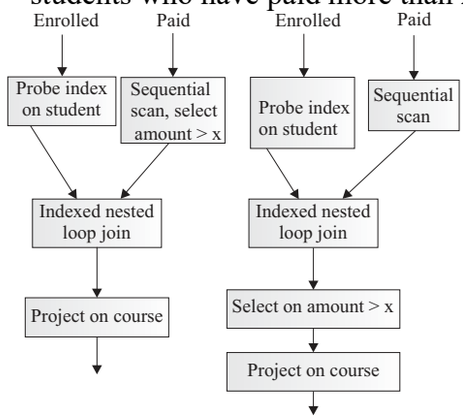
4 Database

1993 IIT Bombay

1. An ISAM (indexed sequential) file consists of records of size 64 bytes each, including key field of size 14 bytes. An address of a disk block takes 2 bytes. If the disk block size is 512 bytes and there are 16K records, compute the size of the data and index areas in terms of number blocks. How many levels of tree do you have for the index?

2006 IIT Kharagpur

2. Consider the relation enrolled (student, course) in which (student, course) is the primary key, and the relation Paid (student, amount) where student is the primary key. Assume no null values and no foreign keys or integrity constraints. Assume that amounts 6000, 7000, 8000, 9000 and 10000 were each paid by 20% of the students. Consider these query plans (Plan 1 on left, Plan 2 on right) to "list all courses taken by students who have paid more than x".



A disk seek takes 4ms, disk data transfer bandwidth is 300 MB/s and checking a tuple to see if amount is greater than x takes 10μs. Which of the following statements is correct?

(A) Plan 1 and Plan 2 will not output identical row sets for all databases.

(B) A course may be listed more than once in the output of plan 1 for some databases.

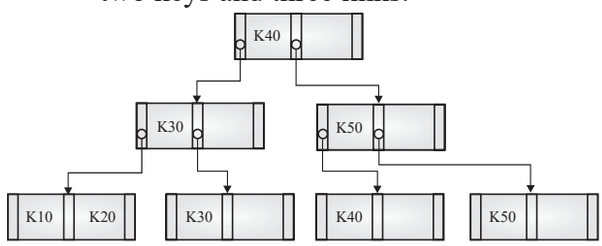
(C) For x = 5000, Plan 1 executes faster than Plan 2 for all databases.

(D) For x = 9000, Plan 1 executes slower than Plan 2 for all databases.

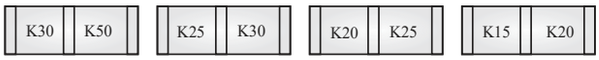
2007 IIT Kanpur

Common Data for Questions 3 & 4

Consider the B+ tree in the adjoining figure, where each node has at most two keys and three links.



3. Keys K15 and then K25 are inserted into this tree in that order. Exactly how many of the following nodes (disregarding the links) will be present in the tree after the two insertions?



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

4. Now the key K50 is deleted from the B+ tree resulting after the two insertions made earlier. Consider the following statements about the B+ tree resulting after this deletion.

i. The height of the tree remains the same.

ii. The node 

(disregarding the links) is present in the tree.

iii. The root node remains unchanged (disregarding the links).

Which one of the following options is true?

(A) Statements (i) and (ii) are true
(B) Statements (ii) and (iii) are true
(C) Statements (iii) and (i) are true
(D) All the statements are false

2008 IISc Bangalore

5. A B-tree of order 4 is built from scratch by 10 successive insertions. What is the maximum number of node splitting operations that may take place?

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

2013 IIT Bombay

6. Relation R has eight attributes ABCDEFGH. Fields of R contain only atomic values.

$F = \{CH \rightarrow G, A \rightarrow BC, B \rightarrow CFH, E \rightarrow A, F \rightarrow EG\}$ is a set of functional dependencies (FDs) so that F^+ is exactly the set of FDs that hold for R.

How many candidate keys does the relation R have?

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

2014 IIT Kharagpur

7. The maximum number of super keys for the relation schema R(E,F,G,H) with E as the key is _____.

2015 IIT Kanpur

8. 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} of which a_{21} is the key attributes. 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_____.

2020 IIT Delhi

9. Consider a relational database containing the following schemas.

Catalogue		
sno	pno	cost
S1	P1	150
S1	P2	50
S1	P3	100
S2	P4	200
S2	P5	250
S3	P1	250
S3	P2	150

S3	P5	300
S3	P4	250

Suppliers		
sno	sname	location
S1	M/s Royal furniture	Delhi
S2	M/s Balaji furniture	Bangalore
S3	M/s Premium furniture	Chennai

Parts		
pno	pname	Part_spec
P1	Table	Wood
P2	Chair	Wood
P3	Table	Steel
P4	Almirah	Steel
P5	Almirah	Wood

The primary key of each table is indicated by underlining the constituent fields.

```
SELECT s.sno, s.sname
FROM Suppliers s, Catalogue c
WHERE s.sno = c.sno AND
cost > (SELECT AVG (cost)
FROM Catalogue
WHERE pno = 'P 4'
GROUP BY pno);
```

The number of rows returned by the above SQL query is

(A) 4 (B) 5

(C) 0 (D) 2

2021 IIT Bombay

10. Let S be the following schedule of operation of three transactions T_1, T_2 and T_3 in a relational database system:

$R_2(Y)$, $R_1(X)$, $R_3(Z)$, $R_1(Y)$, $W_1(X)$, $R_2(Z)$, $W_2(Y)$, $R_3(X)$, $W_3(Z)$

P: S is conflict serializable.

Q: If T_3 commits before T_1 finishes, then S is recoverable.

Which of the following choices is correct ?

(A) Both P and Q are true

(B) P is true and Q is false

(C) Both P and Q are false

(D) P is false and Q is true

Answers Databases

1	3	2	C	3	A	4	A	5	C
6	B	7	8	8	4	9	A	10	B

Explanations Databases

1. 3

Given :

Size of the records = 64 bytes

Address size = 2 bytes

Disk block size = 512 bytes

Number of records = 16K

Index entry size $= 14 + 2 = 16B$

Block factor of record file

$$= \frac{\text{Block size}}{\text{Record size}} = \frac{512B}{64B} = 8$$

Block factor of index file

$$= \frac{\text{Block size}}{\text{Index entry}} = \frac{512B}{16B} = 32$$

Total blocks

$$= \frac{\text{Number of records}}{\text{Block factor of record file}} = \frac{16\text{k}}{8} = 2\text{k}$$

Number of first level blocks $= \left\lceil \frac{2k}{32} \right\rceil = 64$

Number of second level index entries = number of data block needed for data file = 2k

Number of second level index entries = number of first level index block = 64

Number of second level index block

$$= \left\lceil \frac{64}{32} \right\rceil = 2$$

Number of second level index entries =

Number of second level index block = 2

Number of index blocks in level $3 = \left\lceil \frac{2}{32} \right\rceil = 1$

So, number of levels = 3

Hence, the correct answer is 3.

2. (C)

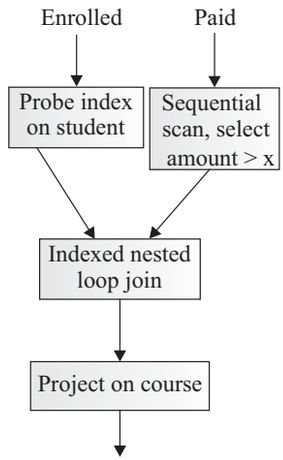
Given:

Enrolled (<u>student, course</u>)

Paid (<u>student</u>, amount)

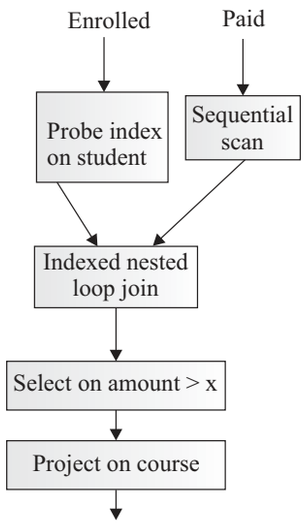
Assume that amounts 6000, 7000, 8000, 9000, 10000 were each paid by 20 % of the students

Plan 1:



Query : Π_{course} (Enrolled $\bowtie$ $\sigma_{amount>x}$(Paid))

Plan 2:



Query : $\Pi_{course}(\sigma_{amount>x}(Enrolled \bowtie Paid))$

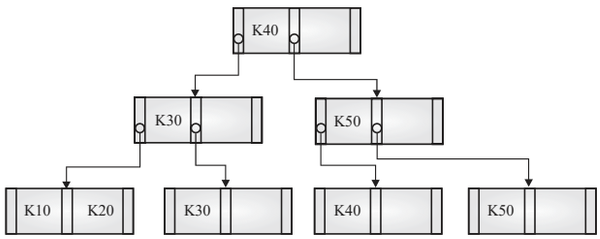
If $X = 5000$ Plan1, Plan2 join cost equal because amounts of Paid relation are greater than 5000.

Between Plan1 required (amount > 5000) comparisons only to Paid relation and Plan2 required (amount > 5000) comparison to the result of Enrolled $\bowtie$ Paid. So that Plan1 executes faster than Plan2 because Plan1 joins Enrolled records with 20 % of Paid records. So that Plan1 executes faster than Plan2 .

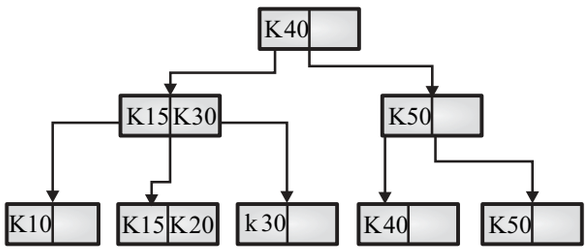
Hence, the correct option is (C).

3 (A)

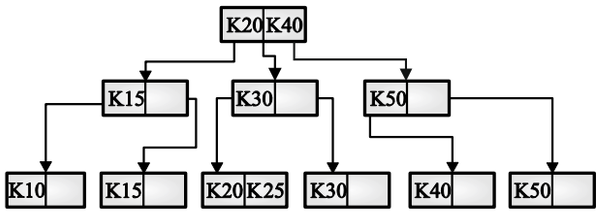
Given :



Tree after inserting K15-



Tree after inserting K25-

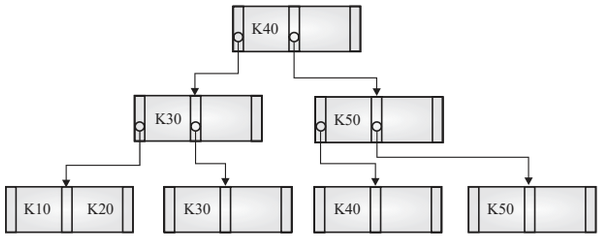


Matching node is $(K\,20, K\,25)$, hence only 1.

Hence, the correct option is (A).

4 (A)

Given :



Key K50 is deleted from B+ tree.

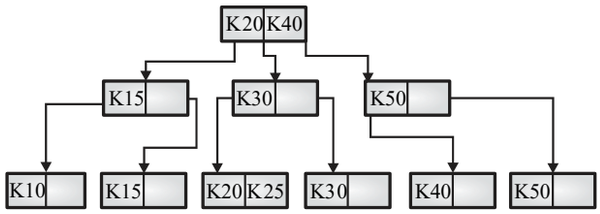
Statements :

i. The height of the tree remains the same.

ii. The node 

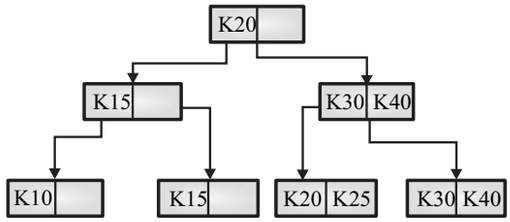
(disregarding the links) is present in the tree.

iii. The root node remains unchanged (disregarding the links).



Consider the following statements about the B+ tree after the deletion

After removing K 50 →



(i) Height of root is same.
True

(ii) The node 

is present in tree.
True

(iii) The root node remains unchanged.
False

Therefore, statement (i) and (ii) are true

Hence, the correct option is (A).

5 (C)

Given :

Order of B tree = 4

Number of successive insertions = 10

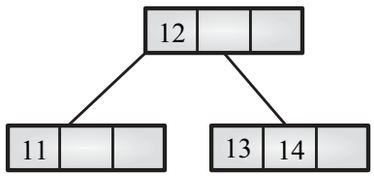
Let us explain this with an example-

Taking 10 values to insert in B tree

{11, 12, 13, …, 20}

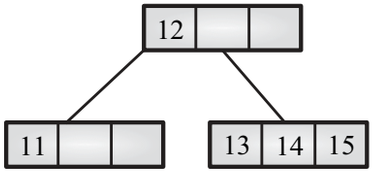
Inserting 11, 12, 13-

Inserting 14

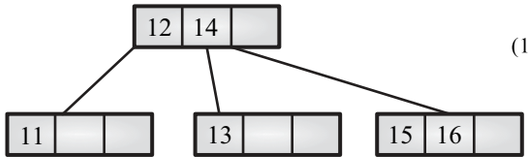


(1split)

Inserting 15

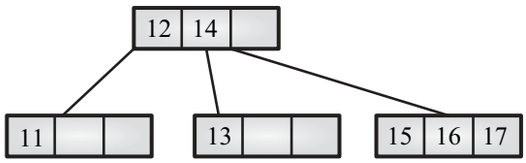


Inserting 16

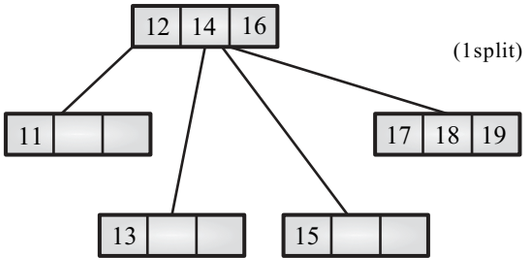


(1split)

Inserting 17

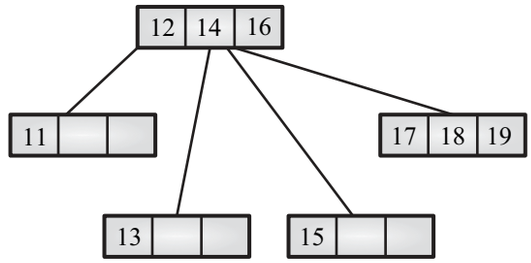


Inserting 18

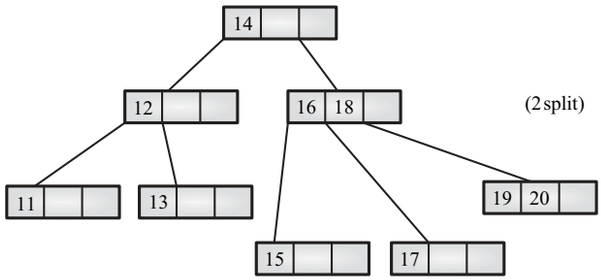


(1split)

Inserting 19



Inserting 20



(2split)

Total splits $= 1+1+1+2 = 5$

Hence, the correct option is (C).

6 (B)

Given : Relation R has eight attributes ABCDEFGH. Fields of R contain only atomic values.

FD : $\{CH \rightarrow G, A \rightarrow BC, B \rightarrow CFH, E \rightarrow A, F \rightarrow EG\}$

The attribute D does not appear on RHS of any functional dependency. Hence, D must be a part of candidate key.

$$D^+ = \{D\}$$

So, adding A, B, C, E, F, G, H to D and checking for the key of size 2

$$(AD)^+ = \{A, B, C, D, F, H, E, G\}$$

$$(BD)^+ = \{B, C, F, H, D, E, G, A\}$$

$$(CD)^+ = \{C, D\}$$

$$(ED)^+ = \{E, D, A, B, C, F, H, G\}$$

$$(FD)^+ = \{F, D, E, G, A, B, C, H\}$$

$$(GD)^+ = \{G, D\}$$

$$(HD)^+ = \{H, D\}$$

Candidate keys of size 2 are – AD, BD, ED, FD. Checking for candidate key of size 3,

(1) We cannot add any attribute to AD, BD, ED, FD as it will just make super keys that are not minimal.

(2) Proceeding with CD, GD and HD, here we cannot add A, B, E, F as it will just make super keys. Adding G, C, H to CD, GD, & HD.

$$(CGD)^+ = \{G, C, D\}$$

$$(CHD)^+ = \{G, H, D, G\}$$

$$(GHD)^+ = \{G, H, D\}$$

Checking for candidate key of size 4,

$$(CGHD)^+ = \{C, G, H, D\}$$

Final set of candidate keys –AD, BD, ED, FD.

Hence, the correct option is (B).

Key Point

If an attribute does not appear in RHS of any of the functional dependencies then that attribute must be part of all candidate keys.

7 8

Given : R(E,F,G,H)

Method 1

E is the key. The attributes other than E, ie. F, G, H will be added in different combination to E and result in super keys.

So, super keys are-

{ E, EF, EG, EH, EFG, EFH, EGH, EFGH }

Hence, the answer is 8

Method 2

The possible keys (i.e. super keys) $= 2^{4-1} = 8$

Key Point

Maximum number of possible super keys for a relation with n attributes having one candidate key with one attribute only $= 2^{n-1}$

Where, n = Total number of attributes.

Hence, the correct answer is 8.

8 4

Given :

E_1 and E_2 are connected by an m: n relationship R_{12}.

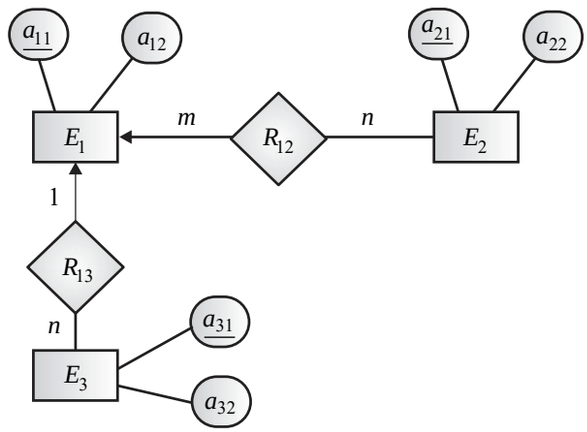
E_1 and E_3 are connected by a l: n (l on the side of E_1 and n on the side of E_3) relationship R_{13}

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} of which a_{21} is the key attributes.

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.



The relations generated are :

For $E_1 = (\underline{a_{11}}, a_{12})\{a_{11} \rightarrow a_{12}\}$

For $E_2 = (\underline{a_{21}}, a_{22})\{a_{21} \rightarrow a_{22}\}$

For E_3 and $E_1 - E_3$ relation

$E_3R_{13} = (\underline{a_{31}}, a_{32}, a_{11})\ \{a_{31} \rightarrow a_{32}a_{11}\}$

For $R_{12} = (\underline{a_{11}}, a_{21})$

R_{13} does not require a separate table because it is a many to one relation.

R_{12} require a separate table because of many to many relationship.

We cannot combine them further because if we combine, they will violate the condition of 3NF. So, Total minimum 4 tables required.

Hence, the correct answer is 4.

9 (A)

Given :

Following relational database scheme :

Catalogue		
<u>sno</u>	<u>pno</u>	cost
S1	P1	150
S1	P2	50
S1	P3	100
S2	P4	200
S2	P5	250
S3	P1	250
S3	P2	150
S3	P5	300
S3	P4	250

Suppliers		
<u>sno</u>	sname	location
S1	M/s Royal furniture	Delhi
S2	M/s Balaji furniture	Bangalore
S3	M/s Premium furniture	Chennai

Parts		
<u>pno</u>	pname	Part_spec
P1	Table	Wood
P2	Chair	Wood
P3	Table	Steel
P4	Almirah	Steel
P5	Almirah	Wood

Query :

Select AVG (cost) from Catalogue where pno = 'P4' GROUPBY pno.

Results in :

<u>sno</u>	<u>pno</u>	cost
S1	P1	150
S1	P2	50
S1	P3	100
S2	P4	200
S2	P5	250
S3	P1	250
S3	P2	150
S3	P5	300
S3	P4	250

First, we will apply groupby P4 and the table will become as shown below :

<u>sno</u>	<u>pno</u>	cost
S1	P1	150
S3	P1	250
S1	P2	50
S3	P2	150
S1	P3	100
S2	P4	200
S3	P4	250
S2	P5	250
S3	P5	300

Now applying groupby we will select all rows having pno= P4 and then find the average cost.

<u>sno</u>	<u>pno</u>	cost
S2	P4	200
S3	P4	250

Average cost $= \frac{200+250}{2}$

$= 225$

Therefore, inner query will return 225.

So, Now Query will become

Select s.sno, s.sname from Supplier s, Catalogue c where s.sno = c. sno AND cost >225

So, here we need to do cross product of Supplier table s and Catalogue table c and from the cross product we will select those rows where s.sno = c.sno AND cost > 225.

Since it is given that cost > 225 so we do not need to consider rows from Catalogue table having cost > 225 while doing cross product.

Hence row number 5, 6, 8, 9 would only be taken while doing cross product.

So, after doing cross product the table will become :

s.sno	s.name	s.location	c.sno	c.pno	c.cost
S1	M/S Royal furniture	Delhi	S2	P5	250
S1	M/S Royal furniture	Delhi	S3	P1	250
S1	M/S Royal furniture	Delhi	S3	P5	300
S1	M/S Royal furniture	Delhi	S3	P4	250
S2	M/S Balaji furniture	Bangalore	S2	P5	250
S2	M/S Balaji furniture	Bangalore	S3	P1	250
S2	M/S Balaji furniture	Bangalore	S3	P5	300
S2	M/S Balaji furniture	Bangalore	S3	P4	250
S3	M/S Premium furniture	Chennai	S2	P5	250
S3	M/S Premium furniture	Chennai	S3	P1	250
S3	M/S Premium furniture	Chennai	S3	P5	300
S3	M/S Premium furniture	Chennai	S3	P4	250

Now after doing cross product only 4 would be selected from the table due to the condition s.sno = c.sno

Final Result :

s.sno	s.name	s.location	c.sno	c.pno	c.cost
S2	M/S Balaji furniture	Bangalore	S2	P5	250
S3	M/S Premium furniture	Chennai	S3	P1	250
S3	M/S Premium furniture	Chennai	S3	P5	300
S3	M/S Premium furniture	Chennai	S3	P4	250

Hence, the correct option is (A).

10 (B)

Given: Transactions with operations :

T1	*T2*	*T3*
	$R_2(y)$	
$R_1(x)$		
		$R_3(z)$
$R_1(x)$	$R_2(z)$	
$W_1(x)$	$W_2(y)$	
		$R_3(X)$
		$W_3(z)$

Statements

P : S is conflict serializable

Q : If T3 commits before T1 finishes, then S is recoverable.

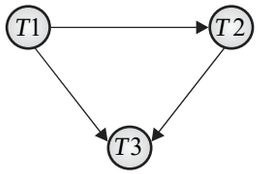
Since,

$T1 \rightarrow T2$ due to $R_1(y)$ is before $W_2(y)$

$T1 \rightarrow T3$ due to $W_1(x)$ is before $R3(X)$

T2 $\rightarrow T3$ due to $R_2(z)$ is before $W_3(z)$ in the schedule

So, precedence graph for the given schedule is:



There are no other conflicts and the discovered conflicts are not forming the cycle. Therefore, given schedule S is conflict serializable.

Therefore, statement P is True.

As we know schedule S is recoverable if Tj creating the dirty read by reading the written data by Ti and Tj commits after Ti commits. Here, transaction T3 performing dirty read of T1 and T3 should commit after T1 to make the schedule recoverable.

Therefore, statement Q is False.

Hence, the correct option is (B).

❖❖❖❖

12 YEARS GATE SOLVED PAPERS

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GATE 2022

GENERAL APTITUDE

UMESH DHANDE

AE AG AR BM BT CY CE CH CS EC EE IN ME PI ES EY GG MA MN MT PE PH ST TF XE XH XL

Topic-wise Previous 12 Years GATE Solutions

- Diligent solutions of GATE previous year questions (2010-2021)
- Multi method approach for a single problem to develop crystal clear concepts
- Video solution for conspicuous questions to enhance problem solving skills

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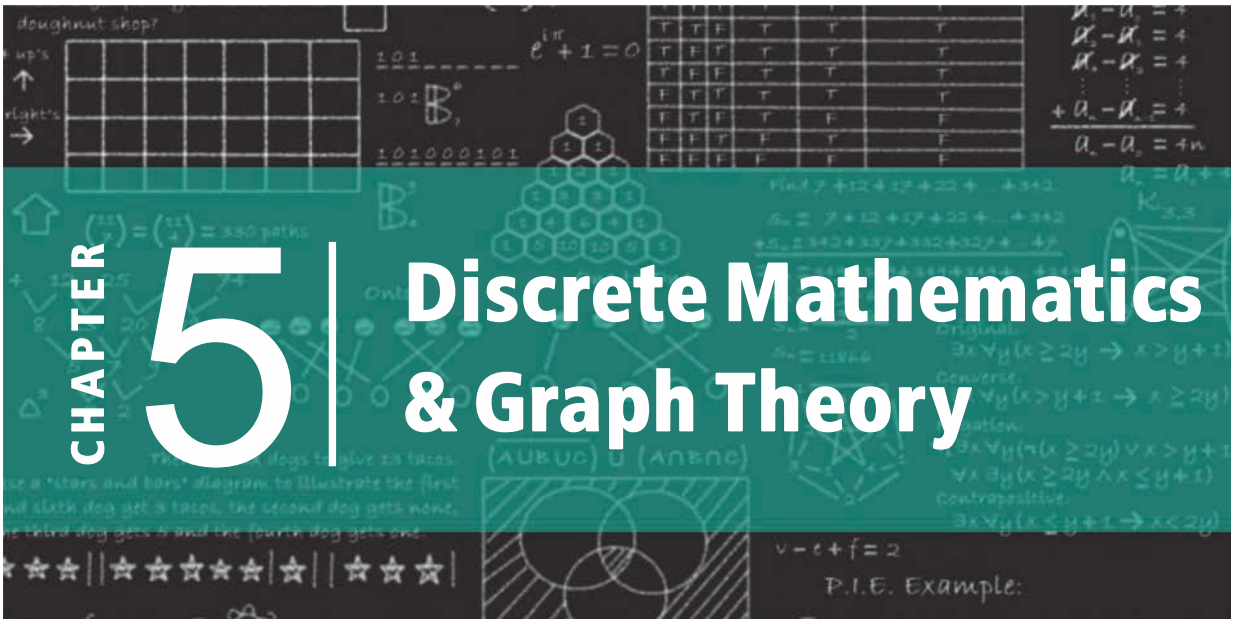


Marks Distribution of Discrete Mathematics & Graph Theory in Previous Year GATE Papers.

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2003	4	9	22
2004*	6	10	26
2005*	6	10	26
2006*	6	12	30
2007*	5	7	21
2008*	3	11	25
2009	4	5	14
2010	3	3	9
2011	1	2	5
2012	2	4	10
2013	2	3	8
2014 Set-1	3	5	13
2014 Set-2	2	5	12
2014 Set-3	3	5	13

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2015 Set-1	3	5	13
2015 Set-2	4	5	14
2015 Set-3	5	4	13
2016 Set-1	2	3	8
2016 Set-2	2	3	8
2017 Set-1	4	1	6
2017 Set-2	3	1	5
2018	3	4	11
2019	3	1	5
2020	2	4	10
2021 Set-1	2	3	8
2021 Set-2	2	3	8

*** CS and IT combined**

Syllabus : Discrete Mathematics & Graph Theory

Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Monoids, Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions.

Contents : Discrete Mathematics & Graph Theory

5 Discrete Mathematics & Graph Theory

2001 IIT Kanpur

1. Consider two well-formed formulas in propositional logic

$F1: P \Rightarrow \neg P$

$F2: (P \Rightarrow \neg P) \vee (\neg P \Rightarrow P)$

Which of the following statements is correct?

(A) F1 is satisfiable, F2 is valid

(B) F1 is unsatisfiable, F2 is satisfiable

(C) F1 is unsatisfiable, F2 is valid

(D) F1 and F2 are both satisfiable

2004 IIT Delhi

2. How many graphs on n labelled vertices exist which have at least $\frac{(n^2-3n)}{2}$ edges?

(A) ${}^{\frac{(n^2-n)}{2}}C_{\frac{(n^2-3n)}{2}}$ (B) $\sum_{k=0}^{\frac{(n^2-3n)}{2}} {}^{(n^2-n)}C_k$

(C) ${}^{\frac{(n^2-n)}{2}}C_n$ (D) $\sum_{k=0}^{n} {}^{\frac{(n^2-n)}{2}}C_k$

2005 IIT Bombay

3. Let R and S be any two equivalence relations on a non-empty set A. Which one of the following statements is TRUE?

(A) $R \cup S$, $R \cap S$ are both equivalence relations

(B) $R \cup S$ is an equivalence relation

(C) $R \cap S$ is an equivalence relation

(D) Neither $R \cup S$ nor $R \cap S$ is an equivalence relation

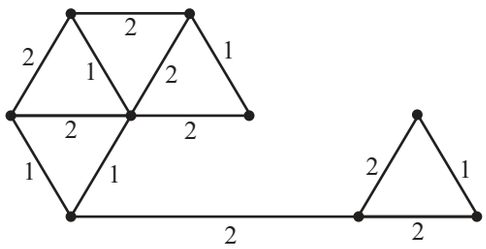
2014 IIT Kharagpur

4. 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 possible 1-pennant is $\{(1)\}$, the set of all possible 2-pennant is $\{(2),(1,1)\}$ and the set of all 3-pennant 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-pennant is _____.

2014 IIT Kharagpur

5. Consider a unidirectional graph G where self-loops are not allowed. The vertex set of G is $\{(i,j): 1 \le i \le 12, 1 \le j \le 12\}$. There is an edge between (a,b) and (c,d) if $|a-c| \le 1$ and $|b-d| \le 1$. The number of edges in this graph is _____.

6. The number of distinct minimum spanning trees for the weighted graph below is_____.



2015 IIT Kanpur

7. The number of divisors of 2100 is____

2016 IISc Bangalore

8. Let a_n be the number of n-bit strings that do NOT contain two consecutive 1s. Which one of the following is the recurrence relation for a_n?

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

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

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

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

2021 IIT Bombay

9. Let p and q be two propositions. Consider the following two formulae in propositional logic.

$$S_1 : (\neg p \wedge (p \vee q)) \rightarrow q$$

$$S_2 : q \rightarrow (\neg p \wedge (p \vee q))$$

(A) Both S_1 and S_2 are tautologies.

(B) Neither S_1 nor S_2 is a tautology.

(C) S_1 is not a tautology but S_2 is a tautology.

(D) S_1 is a tautology but S_2 is not a tautology.

2021 IIT Bombay

10. Let G be a group of order 6, and H be a subgroup of G such that $1 < |H| < 6$. Which one of the following options is correct?

(A) Both G and H may not be cyclic.

(B) Both G and H are always cyclic.

(C) G is always cyclic, but H may not be cyclic.

(D) G may not be cyclic, but H is always cyclic.

Answers Discrete Mathematics & Graph Theory

1	A	2	D	3	C	4	89	5	506
6	6	7	36	8	B	9	C	10	D

Explanations Discrete Mathematics & Graph Theory

1 (A)

Given : Following well-formed formulae :

$F1: P \Rightarrow \neg P$

$F2: (P \Rightarrow \neg P) \vee (\neg P \Rightarrow P)$

Key Point

A formula is satisfiable if it is possible to find an interpretation that makes the formula TRUE, i.e., for some values the formula is TRUE.

A formula is valid if for all values it results in TRUE

Truth table for $F_1 : P \rightarrow \sim P$

p	$p \rightarrow \sim p$	
F	T	hence F_1 is satisfiable but not valid.
T	F	

Truth table for $F_2 : (p \rightarrow \sim p) \vee (\sim p \rightarrow p)$

p	$(p \rightarrow \sim p) \vee (\sim p \rightarrow p)$	
T	T	hence F_2 is tautology
F	T	

Hence, the correct option is (A).

2 (D)

Given :

Number of labelled vertices = n

Number of edges $\geq \dfrac{(n^2 - 3n)}{2}$

Key Point

Maximum number of edges in simple graph $= \dfrac{n(n-1)}{2}$

We have to choose $\dfrac{(n^2-3n)}{2}$ edges among $\dfrac{n(n-1)}{2}$ edges

Number of graphs with at least $\dfrac{(n^2-3n)}{2}$ edges

$$^{\frac{n(n-1)}{2}}C_{\frac{(n^2-3n)}{2}} + {}^{\frac{n(n-1)}{2}}C_{\frac{(n^2-3n)}{2}+1} + \ldots\ldots + {}^{\frac{n(n-1)}{2}}C_{\frac{n(n-1)}{2}} \quad \ldots.(i)$$

Now since $^nC_r = {}^nC_{n-r}$

$$^{\frac{n(n-1)}{2}}C_{\frac{(n^2-3n)}{2}} = {}^{\frac{n(n-1)}{2}}C_{\frac{n(n-1)}{2}-\frac{(n^2-3n)}{2}} = {}^{\frac{n(n-1)}{2}}C_n$$

Using above expression (i) will become,

$$^{\frac{n(n-1)}{2}}C_n + {}^{\frac{n(n-1)}{2}}C_{n-1} + {}^{\frac{n(n-1)}{2}}C_{n-2} + \ldots\ldots\ldots + {}^{\frac{n(n-1)}{2}}C_0$$

$$= \sum_{k=0}^{n} {}^{\frac{n(n-1)}{2}}C_k$$

Hence, the correct option is (D).

3 (C)

Given :

R and S both are equivalence relation :

Let, R and S both are equivalence relation :

For $R \cap S$:

Let, $\forall x \in A\ (x, x) \in R$ and $(x, x) \in S$

$(x, x) \in R \cap S$

$R \cap S$ is reflexive

Let, (x, y) and $(y, x) \in R$

(x, y) and $(y, x) \in S$

(x, y) and $(y, x) \in R \cap S$

$R \cap S$ is symmetric

Let, (x, y) and $(y, z) \in R \cap S$

(x, y) and $(y, z) \in R$ and

(x, y) and $(y, z) \in S$

$(x, z) \in R$ and $(x, z) \in S$

$(x, z) \in R \cap S$

$R \cap S$ is transitive hence equivalence

For $R \cup S$:

Let, $\forall x \in A\ (x, x) \in R$ and $(x, x) \in S$

$(x, x) \in R \cup S$

$R \cup S$ is reflexive

Let, (x, y) and $(y, x) \in R$

(x, y) and $(y, x) \in S$

(x, y) and $(y, x) \in R \cup S$

$R \cup S$ is symmetric

But if (x, y) and $(y, z) \in R \cup S$

It does not imply that (x, y) and $(y, z) \in R$ and (x, y) and $(y, z) \in S$, since it is possible that $(x, y) \in R$ and $(y, z) \in S$ and therefore, (x, y) and $(y, z) \in R \cup S$.

As a result $(x, z) \notin R \cup S$, hence, $R \cup S$ may or may not be equivalence relation.

Example :

Let $R = \{(a,a),(b,b),(a,b),(b,a)\}$

$S = \{(a,a),(b,b),(c,b),(b,c),(c,c)\}$

$R \cup S = \{(a,a),(b,b),(c,c),(b,a),(b,c),(c,b)\}$

is not an equivalence relation because transitive pair (a,c) is not included.

$R \cap S = \{(a,a),(b,b)\}$ is an equivalence relation.

Hence, the correct option is (C).

4 **89**

Given:

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

Method 1

Let, number of n pennants $= f(n)$

$f(1) =$ number of 1 pennant $= 1$

$f(2) =$ number of 2 pennant $= 2$

$f(3) =$ number of 3 pennants $= 3$

Here 3 pennants can be formed by 1 pennant and 2 pennant

So $f(3) = f(2) + f(1)$, similarly it will create a pattern for the subsequent terms, therefore, it creates a recurrence relation,

$f(n) = f(n-1) + f(n-2)$

Hence, $f(10) = f(9) + f(8)$

The series will become

1, 2, 3, 5, 8, 13, 21, 34, 55, 89

Hence $f(10) = 89$

Method 2

10-pennants can be formed in below combinations :

{(1, 1, 1, 1, 1, 1, 1, 1, 1, 1), (1, 1, 1, 1, 1, 1, 2, 2), (1, 1, 1, 1, 2, 2, 2), (1, 1, 2, 2, 2, 2), (2, 2, 2, 2, 2)

Number of 10 pennants = total permutations of above combinations

$$= 1 + \frac{9!}{8!} + \frac{8!}{6!2!} + \frac{7!}{4!3!} + \frac{6!}{2!4!} + 1 = 89$$

Method 3

Let there be x_1 ones and x_2 twos,

So In 10-pennant

$$x_1 + 2x_2 = 10 \qquad \ldots (i)$$

all possible solutions of equation (i) are :

(0, 5), (2, 4), (4, 3), (6, 2), (8, 1) and (10, 0)

The number of ordered permutations for above solutions are

$$\frac{5!}{5!}=1,\frac{6!}{2!4!}=15,\frac{7!}{4!3!}=35,\frac{8!}{6!2!}=28,\frac{9!}{8!}=9,\frac{10!}{10!}=1$$

So total number of 10 pennants

$$=1+15+35+28+9+1$$
$$=89$$

Hence, the correct answer is 89.

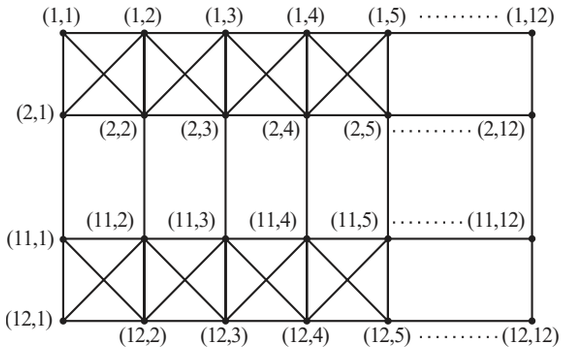
5 (506)

Given : $G=\{(i,j)\,|\,1\le i\le 12, 1\le i\le 12\}$

There is an edge between (a, b) and (c, d) if $|a-c|\le 1$ and $|b-d|\le 1$

So, edges will exist between vertices if the distance is at most 1.

Diagrammatic representation :



From above diagram :

Horizontal edges on each row $=11$

$\Rightarrow$ Total horizontal edges $=11\times12=132$

Similarly,

Total vertical edges $=11\times12=132$

There are 11×11 such square boxes and each box contains 2 diagonal edges.

$\Rightarrow$ Total diagonal edges $=11\times11\times2=242$

Total edges $=132+132+242$

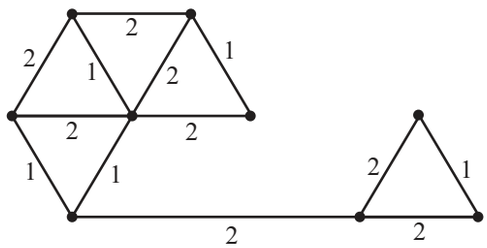
$=506$

Hence, the correct answer is 506.

6 6

Given :

We need to find MST for following graph:

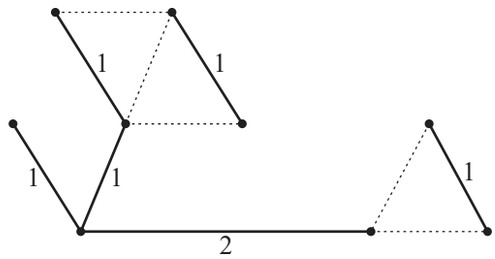


Key Point

Use Kruskal's algorithm to find MST. Kruskal's algorithm.

1. Sort all the edges in non-decreasing order
2. Pick the smallest edge, check if it forms cycle, if not add it.
3. Repeat this step until all the vertices are connected.

Possible MST for given graph is:



In above diagram, solid line represents compulsory edges while dotted line represent choice.

So, we have $3\times2=6$ Choices

Number of distinct minimum spanning trees $=6$

Hence, the correct answer is 6.

7 36

Key Point

If $N=p^a\times q^b\times r^c$, the number of divisor $=n=(p+1)\times(q+1)\times(r+1)$

Given: $N = 2100$

Divisor of $N = 2^2 \times 3^1 \times 5^2 \times 7^1$

Number of divisor

$$= (2+1)\times(1+1)\times(2+1)\times(1+1)$$
$$= 3\times2\times3\times2$$
$$= 36$$

Hence, the correct answer is 36.

8 B

Given : a_n = number of n-bit strings that do NOT contain two consecutive 1's.

Method 1

$a_1 = 2\{0,1\}$

$a_2 = 3\{00,01,10\}$

$a_3 = 5\{000,010,100,001,101\}$

$a_4 = 8\{0000,0001,0100,0101,1000,1001,0010,1010\}$

From above observation we can find the pattern and conclude:

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

Method 2

a_n : denotes number of n-bit strings that do NOT contain two consecutive 1s (valid strings)

Last bit for a_n can be either 0 or 1,

Case 1: If it is 0, then all rest of the bits still keep it a valid string of length n–1 and number of such strings $= a_{n-1}$. Hence all the valid string of length $n-1$, contributes to a_n by using 0 as last bit.

Case 2: If last bit is 1, we have to go on to check $(n-1)^{th}$ or simply second last bit because if its 1 too then our desired string ends with 11, which will make it invalid string, therefore the second last bit must be zero, after this we got to know that last two bit which we should append at last of a valid string is 01, hence all the valid string of length $n-2$ also contributes to a_n by using 01 as last two bits.

Hence $a_n = a_{n-1} + a_{n-2}$, is the correct recurrence relation.

Hence, the correct option is (B).

9 (C)

Given : Following well-formed formulae :

$S_1 : (\neg p \wedge (p \vee q)) \rightarrow q$

$S_2 : q \rightarrow (\neg p \wedge (p \vee q))$

Method 1

S_1 can be written as : $(p'(p+q))'+q$

Simplifying S_1 : $(p+(p+q)')+q$

$$= (p+(p'q'))+q$$
$$= (p+p')(p+q')+q$$
$$= p+q'+q$$
$$= 1$$

Hence S_1 is tautology.

S_2 can be written as : $q'+(p'(p+q))$

Simplifying S_2 :

$$q'+(pp'+p'q)$$
$$q'+(p'q)$$
$$q'+p'$$

Which is not always 1. Hence S_2 is not tautology.

Hence, the correct option is (C).

Method 2

$$S_1 :\sim p \wedge (p \vee q) \rightarrow q$$

if consequence is false and hypothesis is true, then we will get False in the truth table.

Let assume q is false, so consequence is FALSE.
can it make Hypothesis TRUE ?

Hypothesis :

$$\sim p \wedge (p \vee q) \equiv \sim p \wedge (p \vee \text{False})$$
$$\equiv \sim p \wedge (p) \equiv (\text{False})$$

Hypothesis can't be true, so we can't get False in the Truth Table.

$\therefore$ S_1 is Tautology.

S_2 : $q \rightarrow \sim p \wedge (p \vee q)$: if hypothesis is true and consequence is false, then we will get False in the truth table. let assume q is True, So Hypothesis is TRUE. can it make Consequence FALSE ?

Consequence:

$$\sim p \wedge (p \vee q) \equiv \sim p \wedge (p \vee \text{TRUE})$$
$$\equiv \sim p \wedge (\text{TRUE}) \equiv \sim p$$

p can be true, so we can get False in the Truth Table.

$\therefore$ S_2 is not Tautology.

Hence, the correct option is (C).

10 (D)

Given : G is a group of order 6.

Key Point

Lagrange's Theorem: The order of every subgroup of G divides the order of G

So, Subgroup (H) of G can be the order of 1,2,3,6.

Key Point

The Group of prime order is cyclic

If order of G = 6 which is not a prime number so **G may or may not be cyclic.**

If order of H = 1 or 2 or 3, since 2,3 are prime numbers and Group with 1 element is always cyclic. Therefore, **H is always cyclic.**

Hence, the correct option is (D).

❖❖❖❖

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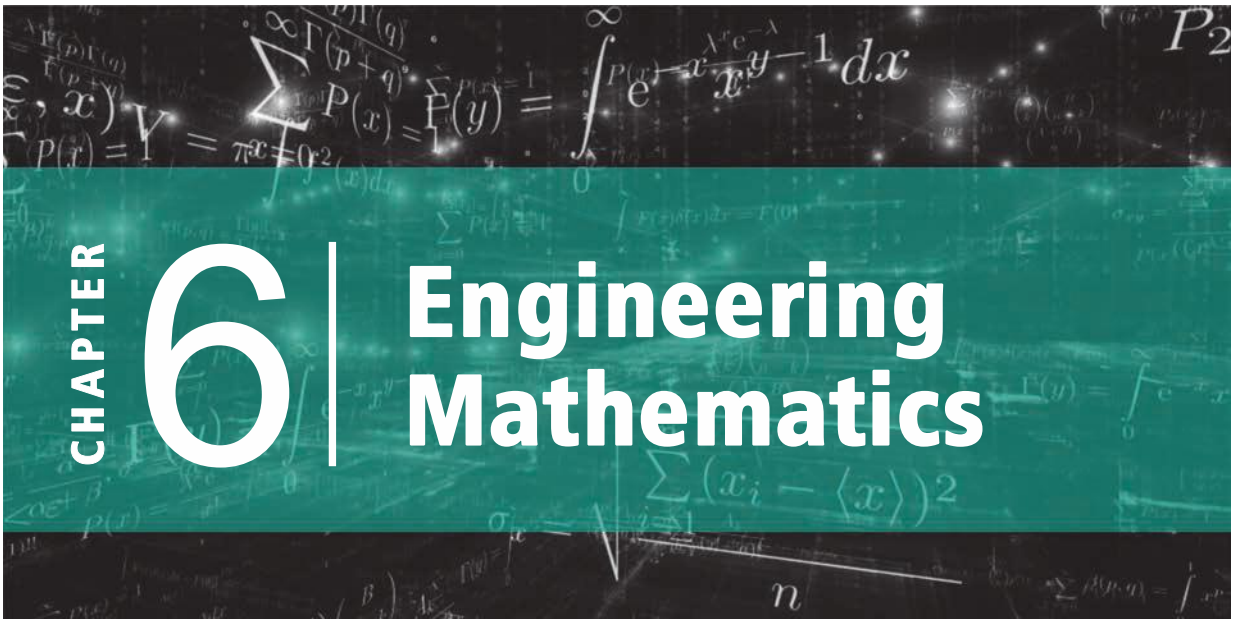


CHAPTER 6 Engineering Mathematics

Marks Distribution of Engineering Mathematics in Previous Year GATE Papers.

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2003	1	4	9
2004	5	6	17
2005	3	4	11
2006	2	4	10
2007	3	5	13
2008	3	8	19
2009	-	3	6
2010	1	3	7
2011	2	4	10
2012	3	2	7
2013	4	-	4
2014 Set-1	4	3	10
2014 Set-2	3	3	9
2014 Set-3	3	3	9

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2015 Set-1	3	2	7
2015 Set-2	1	2	5
2015 Set-3	2	2	6
2016 Set-1	3	2	7
2016 Set-2	4	-	4
2017 Set-1	2	3	8
2017 Set-2	3	4	11
2018	3	2	7
2019	3	2	7
2020	1	2	5
2021 Set-1	2	2	6
2021 Set-2	3	2	7

Syllabus : Engineering Mathematics

Linear Algebra : Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Calculus : Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration.

Probability and Statistics : Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem. Computer Science and Information Technology.

Contents : Engineering Mathematics

6 Engineering Mathematics

1995 IIT Kanpur

1. A bag contains 10 white balls and 15 black balls. Two balls are drawn in succession. The probability that one of them is black and the other is white is

(A) $\frac{2}{3}$ (B) $\frac{4}{5}$

(C) $\frac{1}{2}$ (D) $\frac{2}{1}$

1996 IISc Bangalore

2. Let $AX = B$ be a system of linear equations, where A is an $m \times n$ matrix, B is an $m \times 1$ column matrix and X is $n \times 1$ column vector of unknowns which of the following is false?

(A) The system has a solution if $\rho(A) = \rho(A:B)$

(B) If $m = n$ and B is a non-zero vector then the system has unique solution

(C) If $m < n$ and B is zero vector, then the system has infinitely many solutions

(D) The system will have only a trivial solution when $m = n$, B is the zero vector and rank of A is n

2005 IIT Bombay

3. What are the Eigen values of the following 2×2 matrix?

$$\begin{bmatrix} 2 & -1 \\ -4 & 5 \end{bmatrix}$$

(A) –1 and 1 (B) 1 and 6

(C) 2 and 5 (D) 4 and –1

2006 IIT Kharagpur

4. When a coin is tossed, the probability of getting a head is p, $0 < p < 1$. Let N be the random variable denoting the numbers of tosses till the first Head appears. Assuming that successive tosses are independent, the expected value of N is.

(A) $1/p$ (B) $1/(1-p)$

(C) $1/p^2$ (D) $1/(1-p^2)$

2009 IIT Roorkee

5. $\int_0^{\frac{\pi}{4}} \frac{(1-\tan x)}{(1+\tan x)} dx$ evaluates to

(A) 0 (B) 1

(C) ln 2 (D) $\frac{1}{2}\ln 2$

2014 IIT Kharagpur

6. The product of the non-zero Eigen values 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_____.

2015 IIT Kanpur

7. Let $f(x) = x^{-(1/3)}$ and A denote the area of the region bounded by $f(x)$ and the X-axis, when x varies from -1 to 1. Which of the following statements is/are True ?

1. f is continuous [-1,1]
2. f is not bounded in [-1,1]
3. A is nonzero and finite

(A) 2 only (B) 3 only

(C) 2 and 3 only (D) 1,2 and 3

2016 IISc Bangalore

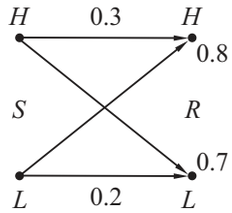
8. Let $f(x)$ be a polynomial and $g(x) = f'(x)$ be its derivative. If the degree of $(f(x) + f(-x))$ is 10, then the degrees of $(g(x) - g(x))$ is _____

2019 IIT Madras

9. Two numbers are chosen independently and uniformly at random from the set {1,2….,13}. The probability (rounded off to 3 decimal places) that their 4-bit (unsigned) binary representations have the same most significant bit is _____.

2021 IIT Bombay

10. A sender (S) transmits a signal, which can be one of the two kinds: H and L with probabilities 0.1 and 0.9 respectively, to a receiver (R). In the graph below, the weight of edge (u, v) is the probability of receiving v when u is transmitted, where u, v ∈ {H. L}. For example, the probability that the received signal is L given the transmitted signal was H. is 0.7.



If the received signal is H, the probability that the transmitted signal was H(rounded to 2 decimal places) is _____.

Answers Engineering Mathematics

1	C	2	B	3	B	4	A	5	D
6	6	7	C	8	9	9	0.503	10	0.04

Explanations Engineering Mathematics

1 (C)

Given: A bag contains 10 white balls and 15 black balls. Total balls in bag = 10 + 15 = 25

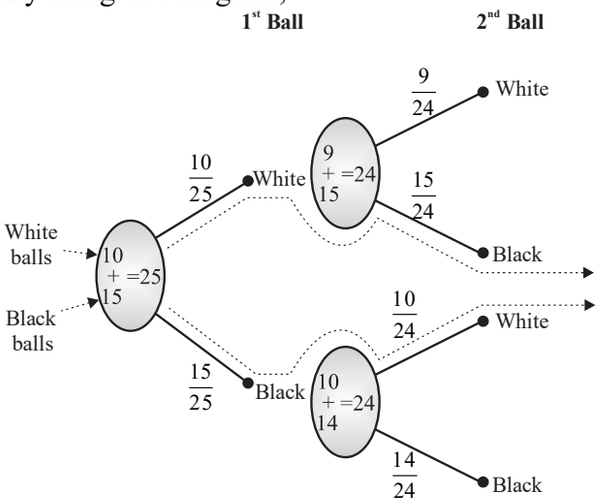
Method 1

Probability that one of them is black and the other is white $= \frac{{}^{10}C_1 \times {}^{15}C_1}{{}^{25}C_2} = \frac{1}{2}$

Hence, the correct option is (C).

Method 2

By using tree diagram,



Total probability $= \underbrace{\frac{10}{25}}_{\text{White}} \times \underbrace{\frac{15}{24}}_{\text{Black}} + \underbrace{\frac{15}{25}}_{\text{Black}} \times \underbrace{\frac{10}{24}}_{\text{White}} = \frac{1}{2}$

Hence, the correct option is (C).

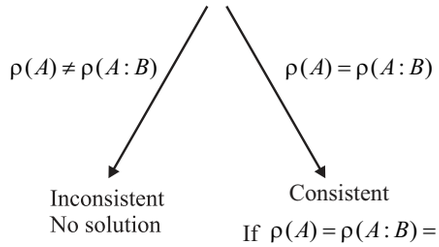
2 (B)

Given :

$AX = B$ is a system of linear equation.

A is $m \times n$ matrix and B is $m \times 1$ matrix.

Augmented matrix is $[A:B]$



Therefore, if $m = n$ and B is non zero vector, then it is not necessary that system has unique solution, because m is number of equation and not number of linearly independent equation.

Hence, the correct option is (C).

3 (B)

Given : $A = \begin{bmatrix} 2 & -1 \\ -4 & 5 \end{bmatrix}$

Method 1

The characteristic equation of this matrix is given by

$$|A - \lambda I| = 0$$

$$\begin{vmatrix} 2-\lambda & -1 \\ -4 & 5-\lambda \end{vmatrix} = 0$$

$$(2-\lambda)(5-\lambda) - 4 = 0$$

$$\lambda^2 - 7\lambda + 6 = 0$$

$$\lambda = 1, 6$$

$\therefore$ The Eigen values of A are 1 and 6.

Hence, the correct option is (B).

Method 2

From the property of eigen values

(i) Trace of matrix = sum of eigen values

(ii) Determinant of matrix = product of eigen values

$$A=\begin{bmatrix}2 & -1\\ -4 & 5\end{bmatrix}$$

Trace of matrix $A=2+5=7$

Determinant of matrix $A=2\times5-1\times4$

$$|A|=10-4$$

$$|A|=6$$

Checking from options

Option (A) :

Sum of eigen value $=-1+1=0\neq$ Trace (A)

So, option (A) is incorrect.

Option (B) :

Sum of eigen value $=6+1=7=$ Trace (A)

Product of eigen value $=6\times1=6=|A|$

Hence, the correct option is (B).

4 (A)

Method 1

The number of attempts to first success follows geometric distribution. It is well known that the expected value in geometric distribution

$$E(X)=\frac{1}{p}$$

Where p is the probability of success in any one attempt.

Hence, the correct option is (A).

Method 2

Let X be the number of attempts to first success.

Let p be the probability of success in any one attempt.

Not the probability distribution table of X is given below :

X	1	2	3	4
$P(X)$	p	$(1-p)p$	$(1-p)^2p$	$(1-p)^3p$

$$E(X)=\Sigma XP(X)$$

$$=1\times p+2\times(p-1)p+3\times(p-1)^2p+.....$$

This is arithmetic geometric series which can be solved as

$$E(X)=\frac{1}{p}$$

Hence, the correct option is (A).

5 (D)

Given : $I=\int_0^{\pi/4}\frac{1-\tan x}{1+\tan x}dx$

Method 1

From property of definite integral

$$\int_0^a f(x)\,dx=\int_0^a f(a-x)\,dx$$

$$\therefore\quad I=\int_0^{\pi/4}\frac{1-\tan\left(\frac{\pi}{4}-x\right)dx}{1+\tan\left(\frac{\pi}{4}-x\right)}$$

$$I=\int_0^{\pi/4}\frac{1-\left[\frac{\tan\frac{\pi}{4}-\tan x}{1+\tan\frac{\pi}{4}\tan x}\right]}{1+\left[\frac{\tan\frac{\pi}{4}-\tan x}{1+\tan\frac{\pi}{4}\tan x}\right]}dx$$

$$\left[\because\ \tan(A-B)=\frac{\tan A-\tan B}{1+\tan A\tan B}\right]$$

$$I=\int_0^{\pi/4}\frac{1-\left[\frac{1-\tan x}{1+\tan x}\right]}{1+\left[\frac{1-\tan x}{1+\tan x}\right]}dx$$

$$I=\int_0^{\pi/4}\frac{(1+\tan x)-(1-\tan x)}{(1+\tan x)+(1-\tan x)}dx$$

$$I=\int_0^{\pi/4}\frac{2\tan x}{2}dx$$

$$I=\int_0^{\pi/4}\tan x\,dx=\left[\ln(\sec x)\right]_0^{\pi/4}$$

$$I=\ln\left(\sec\frac{\pi}{4}\right)-\ln(\sec 0)$$

$$I=\ln\left(\sqrt{2}\right)-\ln(1)$$

$$I=\ln\left(2^{1/2}\right)-0=\frac{1}{2}\ln 2$$

Method 2

$$I=\int_0^{\pi/4}\frac{(1-\tan x)}{(1+\tan x)}dx \Rightarrow \int_0^{\pi/4}\frac{1-\frac{\sin x}{\cos x}}{1+\frac{\sin x}{\cos x}}dx$$

$$\Rightarrow \int_0^{\pi/4}\frac{\cos x-\sin x}{\sin x+\cos x}dx$$

Let, $\sin x+\cos x=t$,

Differentiating with respect to x

$$(\cos x-\sin x)dx=dt$$

When $x=0,\ t=\cos 0+\sin 0=1$

When $x=\frac{\pi}{4},\ t=\cos\frac{\pi}{4}+\sin\frac{\pi}{4}=\sqrt{2}$

So, $I=\int_1^{\sqrt{2}}\frac{dt}{t}=\left[\ln t\right]_1^{\sqrt{2}}=\frac{1}{2}\ln 2-\ln 1$

$$I=\frac{1}{2}\ln 2$$

Hence, the correct option is (D).

6 6

Given : $A=\begin{bmatrix}1&0&0&0&1\\0&1&1&1&0\\0&1&1&1&0\\0&1&1&1&0\\1&0&0&0&1\end{bmatrix}$

Characteristic equation is given by,

$$|A-\lambda I|=\begin{vmatrix}1-\lambda&0&0&0&1\\0&1-\lambda&1&1&0\\0&1&1-\lambda&1&0\\0&1&1&1-\lambda&0\\1&0&0&0&1-\lambda\end{vmatrix}$$

$$|A-\lambda I|=[1-\lambda]\begin{vmatrix}1-\lambda&1&1&0\\1&1-\lambda&1&0\\1&1&1-\lambda&0\\0&0&0&1-\lambda\end{vmatrix}$$

$$+1\begin{vmatrix}0&1-\lambda&1&1\\0&1&1-\lambda&1\\0&1&1&1-\lambda\\1&0&0&0\end{vmatrix}$$

$$=-[1-\lambda]^2\begin{vmatrix}1-\lambda&1&1\\1&1-\lambda&1\\1&1&1-\lambda\end{vmatrix}$$

$$+1\begin{vmatrix}1-\lambda&1&1\\1&1-\lambda&1\\1&1&1-\lambda\end{vmatrix} \quad \ldots(i)$$

Determinant of $\begin{vmatrix}1-\lambda&1&1\\1&1-\lambda&1\\1&1&1-\lambda\end{vmatrix}$

$$=(1-\lambda)\left[(1-\lambda)^2-1\right]-1[1-\lambda-1]+1[1-(1-\lambda)]$$

$$=(1-\lambda)\left[\lambda^2+1-2\lambda-1\right]-1[-\lambda]+1[1-1+\lambda]$$

$$=1-\lambda\left[\lambda^2-2\lambda\right]+2\lambda$$

$$=\lambda^2-2\lambda-\lambda^3+2\lambda^2+2\lambda$$

$$=-\lambda^3+3\lambda^2 \quad \ldots(ii)$$

From equation (i) and (ii)

$$=-[1-\lambda]^2\left[-\lambda^3+3\lambda^2\right]+1\left[-\lambda^3+3\lambda^2\right]=0$$

$$=\left[-\lambda^3+3\lambda^2\right]\left[1-(1-\lambda)^2\right]=0$$

$$=\left[-\lambda^3+3\lambda^2\right]\left[1-(1+\lambda^2-2\lambda)\right]=0$$

$$=\lambda^2(3-\lambda)(2\lambda-\lambda^2)=0$$

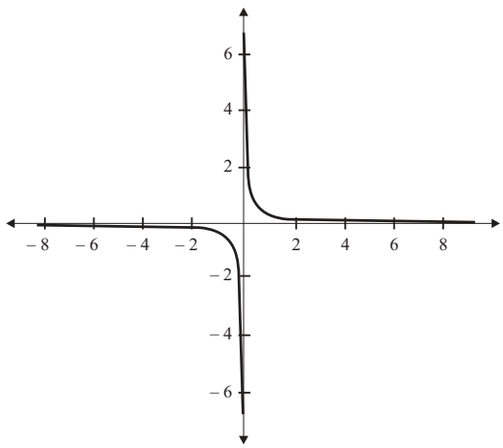
$\therefore$ $\lambda=0,\ \lambda=2,\ \lambda=3$

The product of non-zero Eigen value is $2\times3=6$.

Hence, the correct answer is 6.

7 (C)

Given : $f(x)=x^{\frac{-1}{3}}$



Statement I : f is continuous in [–1, 1]

We need to check continuity at $x=0$

Left hand limit $=\lim\limits_{x\to0^-}\dfrac{1}{\sqrt[3]{x}}=\lim\limits_{h\to0}\dfrac{1}{\sqrt[3]{0-h}}$

$$=\lim_{h\to0}\frac{-1}{\sqrt{h}}=-\infty$$

Right hand limit $=\lim\limits_{x\to0^+}\dfrac{1}{\sqrt[3]{x}}=\lim\limits_{h\to0}\dfrac{1}{\sqrt[3]{0+h}}=\infty$

Left hand limit $\neq$ Right hand limit

$\therefore$ Statement 1 is False

Statement II : f is not bounded in [–1, 1]. Since at $x=0$ it goes to $-\infty$ and $+\infty$ so, the function is not bounded

$\therefore$ Statement 1 is True

Statement III : Area $A=\int\limits_{-1}^{1}f(x)\,dx$

$$A=\int_{-1}^{1}x^{-1/3}\,dx=\left[\frac{x^{1-\frac{1}{3}}}{1-\frac{1}{3}}\right]_{-1}^{1}$$

$$A=\left[\frac{3}{2}x^{2/3}\right]_{-1}^{1}$$

$$A=\frac{3}{2}+\frac{3}{2}=3$$

Area is non zero and finite

So, statement III is true

Hence, the correct option is (C).

8 9

Given : If $f(x)$ is a polynomial of degree 'n'

Then $f'(x)$ is a polynomial of degree $(n-1)$

$f(x)+f(-x)$ is a polynomial of degree 10

$\therefore$ $g(x)-g(-x)$ is a polynomial of degree 9

Hence, the correct answer is 9.

Key Point

If degree of $\{f(x)+f(x)\}=n$, then the largest even exponent of x in $f(x)=n$.

If $g(x)=f'(x)$

Then, the largest odd exponent of x in $g(x)=n-1$

$\therefore$ Degree of $\{g(x)-g(-x)\}=n-1$

9 0.503

Given: Two numbers are choosen randomly from set {1,2,3…13}

4 bit binary representation is of this set will be,

Decimal	Binary			
	MSB			LSB
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1

From above table we can conclude that

[1 to 7] have same MSB bit as 0.

Number of elements $= 7$

[8-13] have same MSB bit as 1.

Number of elements $= 6$

From question, it is given that

"Two numbers are chosen independently and uniformly at random".

Now, Probability of picking the number with same $MSB(0) = \frac{{}^{7}C_1 \times {}^{7}C_1}{13 \times 13} = \frac{49}{169}$

Probability of picking the number with same

$$MSB(1) = \frac{{}^{6}C_1 \times {}^{6}C_1}{13 \times 13} = \frac{36}{169}$$

$$\text{Total probability} = \frac{49}{169} + \frac{36}{169} = \frac{85}{169} = 0.503$$

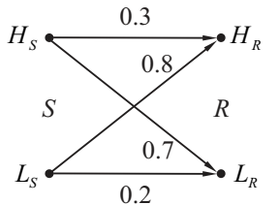
Hence, the correct answer is 0.503.

10 0.04

Given : On sender side

$$P(H_S) = 0.1 \text{ and } P(L_S) = 0.9$$

Probability of received signal is L given transmitted signal is H is $P\left(\frac{L}{H}\right) = 0.7$



If received signal is H, then probability that transmitted was H is

$$P\left(\frac{H_S}{H_R}\right) = \frac{P(H_R / H_S)P(H_S)}{P(H_R)}$$

$$P\left(\frac{H_S}{H_R}\right) = \frac{0.3 \times 0.1}{P(H_R / H_S)P(H_S) + P(H_R / L_S)P(L_S)}$$

$$P\left(\frac{H_S}{H_R}\right) = \frac{0.3 \times 0.1}{0.3 \times 0.1 + 0.8 \times 0.9}$$

$$P\left(\frac{H_S}{H_R}\right) = \frac{0.03}{0.75} = 0.04$$

Hence, the correct answer is 0.04.

❖❖❖❖

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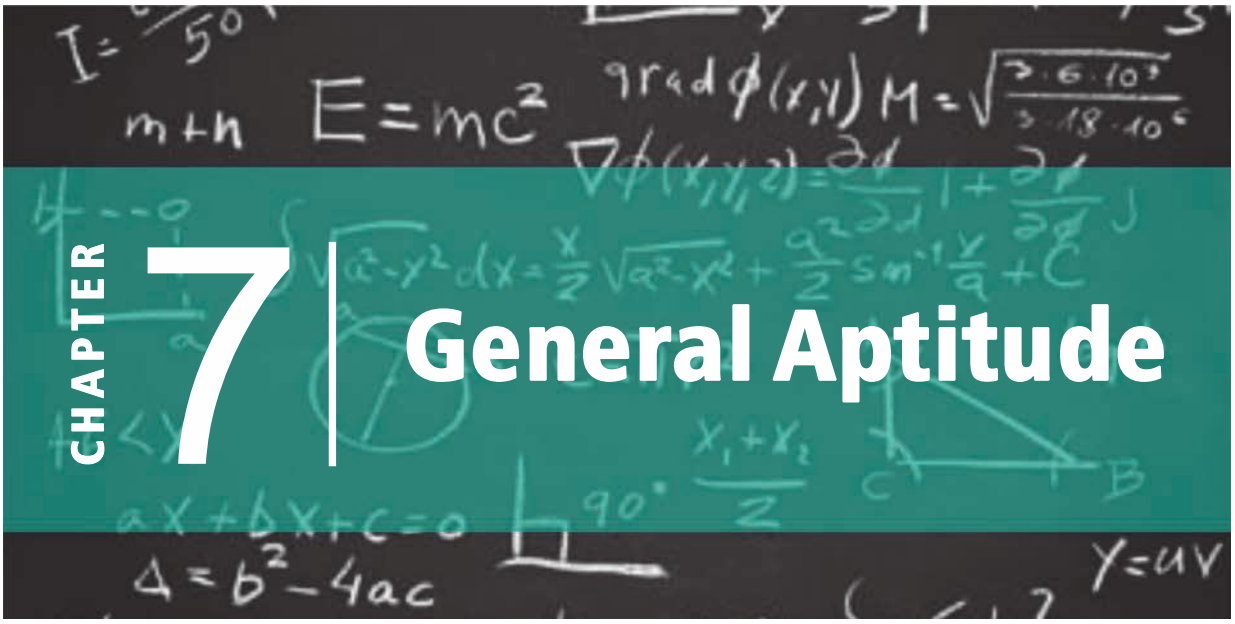


Marks Distribution of General Aptitude in Previous Year GATE Papers.

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2010	5	5	15
2011	5	5	15
2012	5	5	15
2013	5	5	15
2014 Set-1	5	5	15
2014 Set-2	5	5	15
2014 Set-3	5	5	15
2015 Set-1	5	5	15
2015 Set-2	5	5	15
2015 Set-3	5	5	15

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2016 Set-1	5	5	15
2016 Set-2	5	5	15
2017 Set-1	5	5	15
2017 Set-2	5	5	15
2018	5	5	15
2019	5	5	15
2020	5	5	15
2021 Set-1	5	5	15
2021 Set-2	5	5	15

Syllabus : General Aptitude

Verbal Aptitude :

Basic English grammar: tenses, articles, adjectives, prepositions, conjunctions, verb-noun agreement, and other parts of speech Basic vocabulary: words, idioms, and phrases in context Reading and comprehension Narrative sequencing.

Quantitative Aptitude :

Data interpretation: data graphs (bar graphs, pie charts, and other graphs representing data), 2- and 3-dimensional plots, maps, and tables Numerical computation and estimation: ratios, percentages, powers, exponents and logarithms, permutations and combinations, and series Mensuration and geometry Elementary statistics and probability.

Analytical Aptitude :

Logic: deduction and induction Analogy, Numerical relations and reasoning.

Spatial Aptitude :

Transformation of shapes: translation, rotation, scaling, mirroring, assembling, and grouping Paper folding, cutting, and patterns in 2 and 3 dimensions.

Contents : General Aptitude

7 General Aptitude

2012 IIT Delhi

1. An automobile plant contracted to buy shock absorbers from two suppliers X and Y. X supplies 60% and Y supplies 40% of the shock absorbers. All shock absorbers are subjected to a quality test. The ones that pass the quality test are considered reliable. Of X's shock absorbers, 96% are reliable. Of Y's shock absorbers, 72% are reliable. The probability that a randomly chosen shock absorber, which is found to be reliable, is made by Y is

(A) 0.288 (B) 0.334
(C) 0.667 (D) 0.720

2015 IIT Kanpur

2. Four branches of a company are located at M, N, O and P. M is north of N at a distance of 4 km; P is south of O at a distance of 2 km; N is south-east of O by 1 km. What is the distance between M and P in km?

(A) 5.34 (B) 6.74
(C) 28.5 (D) 45.49

3. The head of a newly formed government desires to appoint five of the six selected members P, Q, R, S, T and U to portfolios of Home, Power, Defense, telecom and Finance. U does not want any portfolio if S gets one of the five. R wants either Home or Finance or no portfolio. Q says that if S gets either Power or Telecom, then she must get the other one. T insists on a portfolio if P gets one.

Which is the valid distribution of portfolio?

(A) P-Home, Q-Power, R-Defense, S-Telecom, T-Finance
(B) R- Home, S-Power, P-Defense, Q-Telecom, T-Finance
(C) P- Home, Q-Power, T-Defense, S-Telecom, U-Finance
(D) Q- Home, U-Power, T-Defense, R-Telecom, P-Finance

2016 IISc Bangalore

4. A cube is built using 64 cubic blocks of side one unit. After it is built, one cubic block is removed from every corner of the cube. The resulting surface area of the body (in square units) after the removal is _____.

(A) 56 (B) 64
(C) 72 (D) 96

2017 IIT Roorkee

5. Find the smallest number y such that $y \times 162$ is a perfect cube.

(A) 24 (B) 27
(C) 32 (D) 36

6. Choose the option with words that are not synonyms.

(A) Aversion, dislike

(B) Luminous, radiant

(C) Plunder, loot

(D) Yielding, resistant

2021 IIT Bombay

7. We have 2 rectangular sheets of paper, M and N, of dimensions $6\text{ cm} \times 1\text{cm}$ each. Sheet M is rolled to form an open cylinder by bringing the short edges of the sheet together. Sheet N is cut into equal square patches and assembled to form the largest possible closed cube. Assuming the ends of the cylinder are closed, the ratio of the volume of the cylinder to that of the cube is _____.

(A) $\frac{9}{\pi}$ (B) 3π

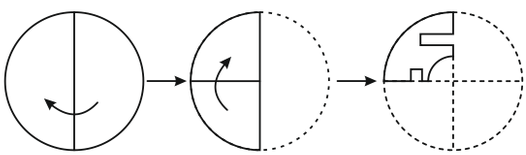
(C) $\frac{\pi}{2}$ (D) $\frac{3}{\pi}$

8. A polygon is convex if, for every pair of points P and Q belonging to the polygon, the line segment PQ lies completely inside or on the polygon.

Which one of the following is NOT a convex polygon?

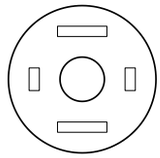
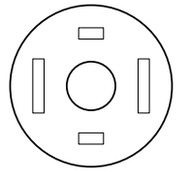
(A)  (B) 

(C)  (D) 

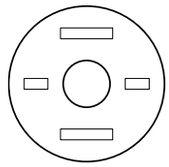
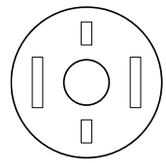
9. 

A circular sheet of paper is folded along the lines in the directions shown. The paper, after being punched in the final folded state as shown and unfolded in the reverse order of folding, will look like_____.

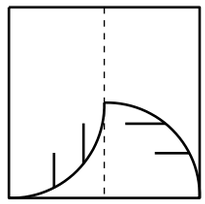
(A) (B)

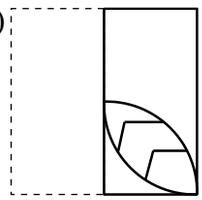
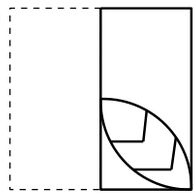
 

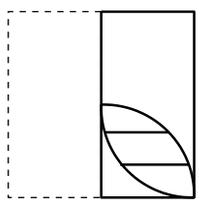
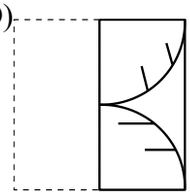
(C) (D)

10. A transparent square sheet shown below is folded along the dotted line. The folded sheet will look like_____



(A)  (B) 

(C)  (D) 

Answers General Aptitude

1	B	2	A	3	B	4	D	5	D
6	D	7	A	8	C	9	A	10	A

Explanations General Aptitude

1 (B)

Given :

(i) Probability that shock absorbers are supplied by $X = 0.6$

(ii) Probability that shock absorbers are supplied by $Y = 0.4$

(iii) 96% of X's shock absorbers are reliable

i.e. $= 0.6 \times 0.96$

(iv) 72% of Y's shock absorbers are reliable

i.e. $= 0.4 \times 0.72$

Method 1

According to Bayes' theorem, the probability that a randomly chosen shock absorber is found to be reliable, is supplied by Y is,

$$P\left(\frac{Y}{R}\right) = \frac{P(Y \cap R)}{P(R)} \quad \ldots (i)$$

Where, $P(R) =$ Probability that shock absorber is reliable

$P(R) =$ Reliable when supplied by X + Reliable when supplied by Y

$P(R) = 0.6 \times 0.96 + 0.4 \times 0.72$

$P(R) = 0.864 \quad \ldots (ii)$

$P(Y \cap R) =$ Probability that shock absorber is supplied by Y and is reliable

$P(Y \cap R) = 0.4 \times 0.72 = 0.288 \quad \ldots (iii)$

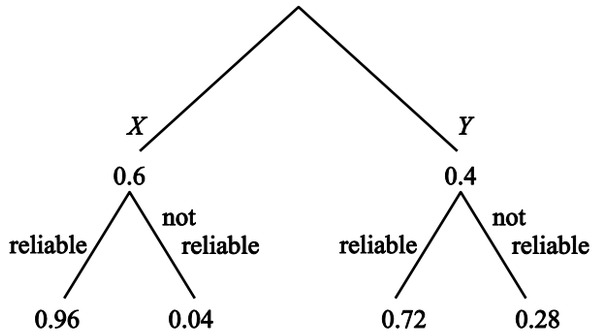
From equations (i), (ii) and (iii),

$$P\left(\frac{Y}{R}\right) = \frac{0.288}{0.864} = 0.334$$

Hence, the correct option is (B).

Method 2

From given information we can draw,

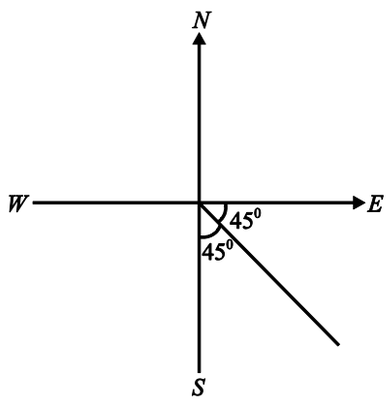


By Bayes' theorem the probability that a randomly chosen shock absorber which is reliable, is made by Y is,

$$= \frac{0.72 \times 0.4}{0.72 \times 0.4 + 0.96 \times 0.6} = 0.33$$

Hence, the correct option is (B).

2 (A)

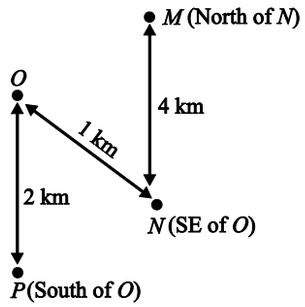


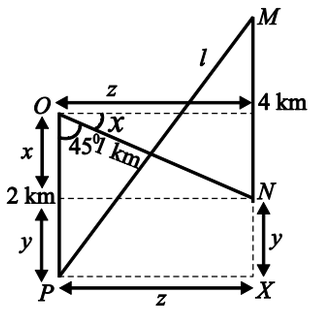
M is north of N, at a distance of 4 km.

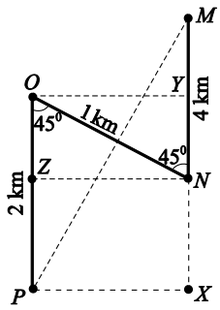
P is south of O, at a distance of 2 km

N is south-east of O by 1 km

Distance between M and P is







From ONY triangle,

$$NY = NO\cos 45^0 = \frac{1}{\sqrt{2}}$$

$$PX = OY = NO\sin 45^0 = \frac{1}{\sqrt{2}}$$

$$NY = OZ = \frac{1}{\sqrt{2}}$$

Thus, $ZP = NX = 2 - \frac{1}{\sqrt{2}} = 1.3$

$$MX = 4 + 1.3 = 5.3$$

By Pythagoras theorem in ΔMXP,

$$(MP)^2 = (MX)^2 + (PX)^2$$

$$(MP)^2 = 5.3^2 + 0.707^2 \quad [PX = OY]$$

$$MP = 5.34 \text{ km}$$

Hence, the correct option is (A).

3 (B)

Given :

(i) There are 5 portfolios, home, power, defense, telecom and finance.

(ii) 6 selected members P, Q, R, S, T and U are to be appointed in 5 portfolios.

(iii) U does not want any portfolio if S gets one of the five.

(iv) R wants either Home or Finance or no portfolio.

(v) Q says that if S gets either Power or Telecom, then she must get the other one. T insists on a portfolio if P gets one.

R wants Home or Finance or no portfolio. In option (A) and (D), R has Defense and Telecom. So, both options are incorrect.

U does not want a portfolio if S gets one of the five. In option (C), S and U both have portfolios.

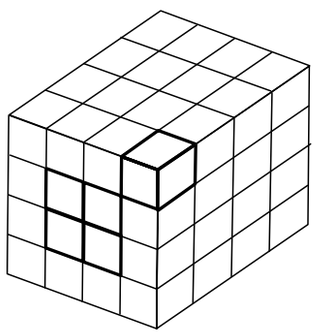
So, option (C) is also incorrect. Hence, the correct option is (B).

4 (D)

Given :

(i) Total number of cubes $= 64$

(ii) Total number of cubes that are removed from each corner $= 08$



Method 1

Area of first face of cube after removal,

$= 12 \times 1 = 12 \text{ m}^2$ [Existing surface]

For six faces, area $= 12 \times 6 = 72 \text{ m}^2$

After removing 8 cubes, visible surface area at each corner $= 03 \times 8 \times 1 = 24\ m^2$

Total surface area $= 72 + 24 = 96\ m^2$

Hence, the correct option is (D).

Method 2

Removed cube will leave same area as they covered before so still area will remain same

Area of one surface $= 16\ unit^2$

and total number of surfaces = 6

Total surface area $= 16 \times 6 = 96\ unit^2$

Hence, the correct option is (D).

5 (D)

Given : $X = y \times 162$

Method 1

Checking from the options,

Option (A) :

$$X = 24 \times 162 = 3888$$

$$(X)^{1/3} = 15.7$$

Incorrect option.

Option (B) :

$$X = 27 \times 162 = 4374$$

$$(X)^{1/3} = 16.3$$

Incorrect option.

Option (C) :

$$X = 32 \times 162 = 5184$$

$$(X)^{1/3} = 17.3$$

Incorrect option.

Option (D) :

$$X = 36 \times 162 = 5832$$

$$(X)^{1/3} = 18$$

Hence, the correct option is (D).

Method 2

Take the prime factor of $162 = 2 \times 81 = 2 \times 9 \times 9$

$$= 2 \times 3 \times 3 \times 3 \times 3$$

Hence, to make it perfect cube, the value of y should be $y = 2 \times 2 \times 3 \times 3 = 36$

Hence, the correct option is (D).

6 (D)

Yielding : Tending to give up under pressure.

Resistant : Offer resistance or opposing.

Luminous : Bright or shining.

Radiant : Glowing brightly

Aversion : Strong dislike

Plunder : Rob or steal goods

Loot : Rob, sack

Yielding and resistant are not synonyms.

Hence, the correct option is (D).

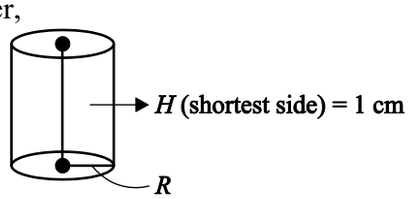
7 (A)

Given :

The dimension of rectangular sheet M and $N = 6\ cm \times 1\ cm$

According to the question,

M is folded along shortest side to form a cylinder,



$$2\pi R = 6\,cm$$

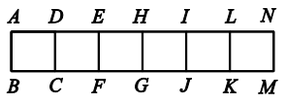
$$R = \frac{3}{\pi}\,cm$$

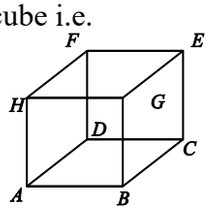
Volume of a right circular cylinder $= \pi R^2 H$

Volume of folded figure $= \pi \times \frac{3}{\pi} \times \frac{3}{\pi} \times 1$

$$= \frac{9}{\pi}\,cm^3$$

N is cutted as square to form a cube i.e.





Since, Volume of cube $= (Side)^3$

Thus, Volume of formed cube from $N = 1\,cm^3$

The ratio of volume of cylinder to cube

$$= \frac{9/\pi}{1} = 9 : \pi$$

Thus, ratio of the volume of the cylinder to that of the cube is $9 : \pi$.

Hence, the correct option is (A).

Key Point

Volume of a right circular cylinder $= \pi R^2 H$

Volume of cube $= (\text{Side})^3$

8 (C)

Given:

We need to identify which one is not a convex polygon

Method 1

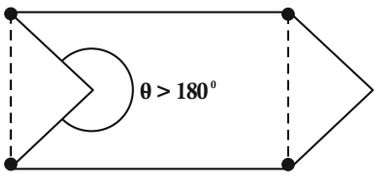
In option (C),

Clearly, we can see that some part is outside the segment line.

Hence, the correct option is (C).

Method 2

Concave polygon is one who have one interior angle more than 180^0.

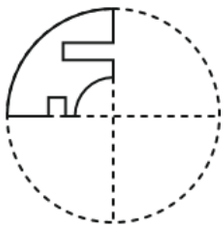


Hence, the correct option is (C).

9 (A)

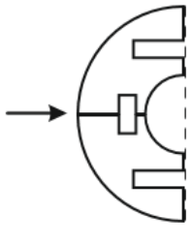
Given :

Initial figure is given below

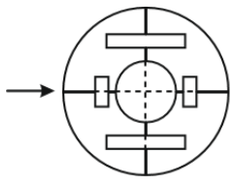


To get the answer, we can simply retrace the steps followed in reverse direction.

Step 1: Create the water image



Step 2: Create the mirror image

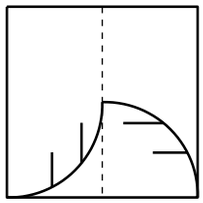


Hence, the correct option is (A).

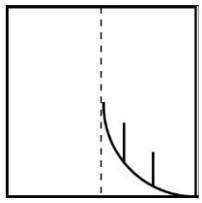
10 (A)

Given:

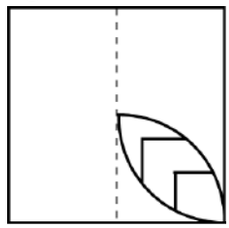
Initial Figure is given below:



Mirror image of the left part of given image is



After combining the above and right part of given image we get,



Hence, the correct option is (A).

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