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GATE
PRACTICE BOOKLET

Computer Science & Information Technology

(Volume - I)

(Database Management Systems, Computer Networks, Algorithms, Data Structures and Programming Languages)

1116 Expected Questions with Solutions

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Syllabus for Computer Science & Information Technology (CSIT)

Discrete Mathematics

Mathematical Logic: Propositional Logic, First-order Logic.

Probability: Random variables and expectation, Conditional probability, Independent random variables, Distributions (Uniform, Normal, Exponential, Poisson, Binomial), Mean, Median, Mode and Standard Deviation.

Set Theory: Sets, Relations, Partial orders, Lattices, Functions, Groups, Recurrence relations, Generating functions.

Combinatorics: Counting, Recurrence relations, Generating functions.

Elementary graph theory: Basic properties, Connectivity, matchings, Coloring.

Linear Algebra: Algebra of Matrices, Determinants, Systems of linear equations, Eigen values & Eigen vectors, LU decomposition for systems of linear equations.

Calculus: Limit, Continuity & Differentiability, Mean value Theorems, Integration, Partial derivatives, Maxima & Minima.

Theory Of Computation

Regular languages and finite automata, Context free languages and Push-down automata, Recursively enumerable sets and Turing machines, Undecidability.

Compiler Design

Lexical analysis, Parsing, Syntax directed translation, Runtime environments, Intermediate code generation.

Database Management Systems

ER-model, Relational Model (Relational Algebra, Tuple Calculus), Database Design (Integrity Constraints, Normal Forms), Query Languages (SQL), File Structures (Sequential Files, Indexing, B and B+ Trees), Transactions and Concurrency Control.

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Computer Networks

Concept of Layering, LAN Technologies (Ethernet), Flow and Error Control Techniques, Switching, IPv4/IPv6, Routers and Routing Algorithms (Distance Vector, Link State), TCP/UDP and Sockets, Congestion Control, Application Layer Protocols (DNS, SMTP, POP, FTP, HTTP), Basics of Wi-Fi. Network Security: Authentication, Basics of Public Key and Private Key Cryptography, Digital Signatures and Certificates, Firewalls.

Data Structures

Arrays, Stacks, Recursion, Queues, Linked Lists, Trees, Binary search trees, AVL trees, Graphs and Hashing

Programming Languages

Programming in C; Recursion

Operating Systems

Processes, Threads, Inter-Process Communication, Concurrency and Synchronization, Deadlock. CPU Scheduling, Memory Management and Virtual Memory, File Systems.

Digital Logic

Boolean Algebra. Combinational and Sequential Circuits. Minimization. Number Representations and Computer Arithmetic (Fixed and Floating Point).

Algorithms

Searching, Sorting, Hashing. Asymptotic Worst Case Time and Space Complexity. Algorithm Design Techniques: Greedy, Dynamic Programming and Divide and Conquer. Graph Search, Minimum Spanning Trees, Shortest Paths.

Computer Organization and Architecture

Machine Instructions and Addressing Modes. ALU, Data-Path and Control Unit. Instruction Pipelining. Memory Hierarchy: Cache, Main Memory and Secondary Storage; I/O Interface (Interrupt and DMA mode).

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Database Management Systems

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Chapter 1 Entity Relationship & Relational Model

01. In E – R model, Y is the dominant entity and X is subordinate entity.
(a) if X is deleted then Y is also deleted
(b) if Y is deleted then X is also deleted
(c) if Y is deleted then X is not deleted
(d) none of the above

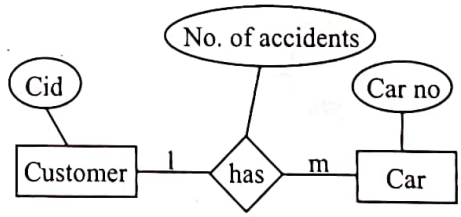
02. Consider the following assumptions for the relation employee(eid, ename, dept, grade, sal, age, address) and find the candidate key of the relation
I. Each employee has unique id
II. An employee can work on one dept only
III. Employees salary depends on his age and grade
IV. Each employee has unique age and address
V. More than one employee can have the same salary or can be of same age

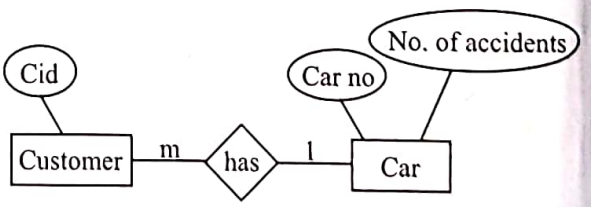
(a) eid only
(b) eid, (age, address)
(c) (grade, age)
(d) eid dept

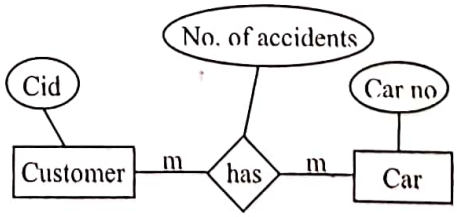
03. 1-N relationships in E-R diagram is implemented in relational model as
(a) Foreign keys are added on both sides
(b) Relation corresponding to '1' side is modified to include foreign key of the relation on the 'N' side
(c) Primary keys are added on both sides
(d) Relation corresponding to 'N' side is modified to include foreign key of the relation on the '1' side.

04. Which of the following statements is True?
(a) The Entity-Relationship data model is an example of implementation data models.
(b) A logical schema can be defined using an E-R model.
(c) E-R model is used in a phase called physical database design.
(d) E-R model is used in a phase called conceptual database design.

05. Construct an E–R model for a car–insurance company that has a set of customers, each of whom owns one or more cars. Each car has associated with it zero to any number of recorded accidents.
Which of the following E – R model satisfies the above business rules?

(a)


(b)


(c)


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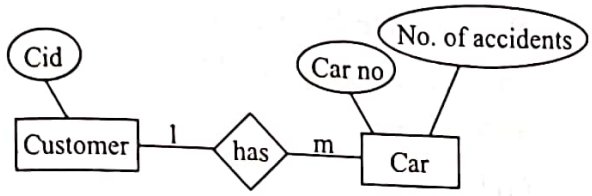
(d)



06. Match the following with most appropriate type of attributes.

List–I

(P) Name of the dependent
(Q) Degree of a person
(R) Telephone number
(S) Date of birth

List–II

(1) Stored attribute
(2) Composite attribute
(3) Multivalued attribute
(4) Discriminator attribute

Codes:

(a) P – 4, Q – 3, R – 2, S – 1
(b) P – 4, Q – 2, R – 3, S – 1
(c) P – 4, Q – 1, R – 2, S – 3
(d) P – 4, Q – 1, R – 3, S – 2

07. All M-N relationships in E-R model are implemented in relational model as

(a) Relation corresponding to M side is modified to include Foreign key of the relation on the 'N' side.
(b) Relation corresponding to 'N' side is modified to include Foreign key of the relation on the 'M'side.
(c) Separate relation is created and primary keys of both M and N are included in the new relation as Foreign keys
(d) Separate relation is created and Foreign keys of both M and N are included in the new relation as Primary keys

08. "Every student has to register a course, every course does not have to have student", what constraint to be used in ER diagram to implement above requirement.

(a) Key constraint
(b) Total participation constraint
(c) Covering constraint
(d) Overlap constraint.

09. The collection of information stored in a database of a particular moment is _____.

(a) view (b) schema
(c) instance (d) subschema

10. The number of rows in a table is known as

(a) Attribute
(b) Tuple
(c) Cardinality
(d) Doesn't describe anything

11. Match the following:

List – I

P. A database schema is
Q. A datamodel is
R. A database instance is

List – II

1. The collection of data stored.
2. A set of concepts used to describe database
3. A description of database using a specific data model.

Codes:

(a) P-3, Q-1, R-2 (b) P-1, Q-3, R-2
(c) P-3, Q-2, R-1 (d) P-2, Q-3, R-1

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12. One to many relationship between X (one side) and Y (many side) entities in ER diagram is converted as
    (a) Modify X side to include foreign key of Y side as primary key
    (b) Modify Y side to include primary key of X side as foreign key
    (c) Modify Y side to include foreign key of Y side as primary key
    (d) Modify X side to include primary key of Y side as foreign key

13. All M-N relationships in E-R model are implemented in relational model as
    (a) Relation corresponding to M side is modified to include Foreign key of the relation on the 'N' side
    (b) Relation corresponding to 'N' side is modified to include Foreign key of the relation on the 'M' side
    (c) Separate relation is created and primary keys of both M and N are included in the new relation as Foreign keys
    (d) Separate relation is created and Foreign keys of both M and N are included in the new relation as Primary keys

14. Construct an E – R model for the below assumption and find out the degree of the relationship.
    A technician uses exactly one notebook for each project.
    Each notebook belongs to one technician for each project.
    Note that a technician may still work on many projects and maintain different notebooks for different projects.
    (a) Unary (b) Binary
    (c) Ternary (d) Two binary relations

15. Convert the following alternatives to E – R model and from E – R model convert them to relational model. Then which of the following alternatives will have only two relations in the relational model.
    (a) A customer have many accounts and an account can be owned by one customer or more
    (b) A supplier supplies many parts and a part can be supplied by many supplies.
    (c) A person can have many loans and a loan is owned by only one person
    (d) A department can have many employees and an employee can work in more than one department.

16. Descriptive attributes are used to
    (a) Record information about participating entities
    (b) Record information about relationships
    (c) Record information about data
    (d) Record information about aggregation

17. A minimum cardinality of zero specifies
    (a) No participation
    (b) Partial participation
    (c) Total participation
    (d) Zero participation

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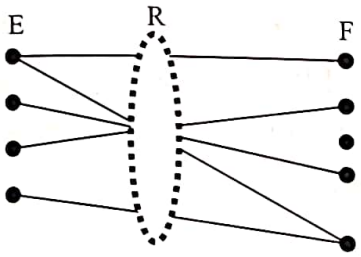
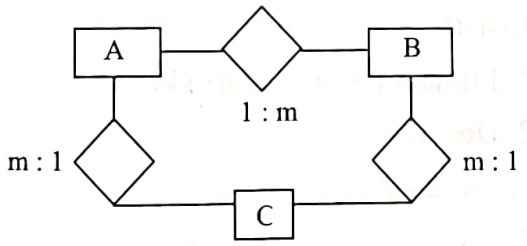
18. Each Employee job can be either a secretary or a technician or an engineer.
Which of the following specialization is suitable based on Job?
(a) Disjoint, partial specialization
(b) Overlapping, partial specialization
(c) Overlapping, total specialization
(d) Disjoint, total specialization

19.



Find the cardinality of R
(a) 1:1 (b) 1 : m
(c) m : 1 (d) m : n

20. Which one of the following statements cannot be made about the following ER diagram?



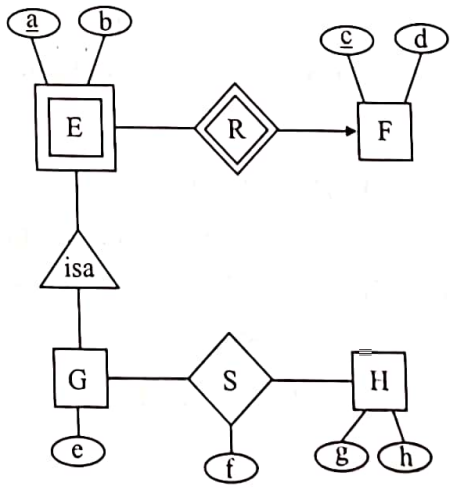
(a) On conversion, we get maximum 6 tables from this ER diagram.
(b) On conversion, we get minimum 3 tables from this ER diagram.
(c) Table A may have primary key of the Table C as primary key.
(d) None

21. What is the type of relationship between weak and strong entity?
(a) 1 : 1 (b) 1 : M
(c) M : 1 (d) M : N

22. Let R be an RDBMS with attributes A_1, A_2,.....,A_n. Let S denotes the set $\{A_1, A_2,\ldots,A_n\}$. Let $T \subset S$ be a set of attributes that forms a candidate key. Then which of the following is/are TRUE?
(P) $T \rightarrow S - T$
(Q) $\exists P \subset T$ s.t. $P \rightarrow S - P$
(R) $\forall Q \supseteq T$ s.t. $Q \rightarrow S - Q$

(a) Only P is TRUE
(b) P and Q are TRUE
(c) P and R are TRUE
(d) Q and R are TRUE

23. Convert the E/R diagram below to a database schema, using the "E/R" method



What is the sum of the number of attributes in each of the relation schemas?
(a) 14 (b) 15
(c) 16 (d) 17

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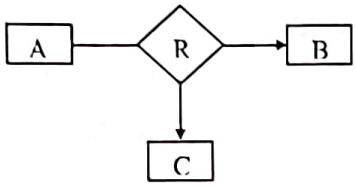
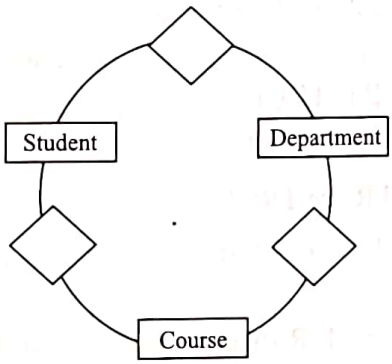
24. Consider the following E/R diagram:



If A has 100 entities, B has 1000 entities, and C has 10 entities, what is the maximum number of triples of entities that could be in the relationship set for R?

(a) 100 (b) 1000
(c) 1,00,000 (d) 10,00,000

Common Data for Q25 & Q26 is given below:



25. Relationship between Student to department is M:1, Department to course is M:N, Student to course is M : N.

Assertion (A): We get Maximum 5 tables while converting this ER diagram to tables.

Reason (R): Only M:N relationships should be converted into tables

(a) Both A & R true & 'R' is the correct explanation of 'A'
(b) Both A & R true & 'R' is the not correct explanation of 'A'
(c) Both 'A' & 'R' are false
(d) 'A' is true, 'R' is False

26. If student entity consists attributes (s1, s2, s3), department with (d1, d2, d3) and course with (c1, c2, c3) then what would be the total number of attributes in Student table on conversion of this ER diagram to tables, if student is a key to the relationship set.. Assume zero attributes for relationships?

(a) 3 (b) 5 (c) 6 (d) 4

27. The terms in list-A have been mapped to list-B so that it corresponds to the mapping process of the ER model into a relational. Which of the following represents the mapping process?

List-A

P. Entity type
Q. Key attributes
R. Composite attributes
S. Multivalued attribute
T. Value set

List-B

1. Primary (or secondary) key
2. Domain
3. Child table
4. Set of simple component attributes
5. Relation

Codes:

	P	Q	R	S	T
(a)	3	1	4	2	5
(b)	5	1	4	3	2
(c)	3	1	4	5	2
(d)	5	1	3	4	2

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28. Match the following with most appropriate type of attributes.

List–I

(P) Name of the dependent

(Q) Degree of a person

(R) Telephone number

(S) Date of birth

List–II

1) Stored attribute

2) Composite attribute

3) Multivalued attribute

4) Discriminator attribute

Codes:

(a) P – 4, Q – 3, R – 2, S – 1

(b) P – 4, Q – 2, R – 3, S – 1

(c) P – 4, Q – 1, R – 2, S – 3

(d) P – 4, Q – 1, R – 3, S – 2

29. Which of the following statement is false?

(a) Every dominant entity is a strong entity

(b) Specialization is done when more than one domain constraint is required on an attribute based on the entity type.

(c) A relationship type can be related to another relationship type

(d) A weak entity will have primary key on its own.

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Solutions

01. Ans: (b)

Sol: When a tuple from the dominant is deleted the related tuple from the subordinate also be deleted.

02. Ans: (b)

Sol: Minimal set of attributes which uniquely identifies each tuple in a relation is said to be candidate key.

03. Ans: (d)

Sol: As N side is a key constraint to the relationship set, then 'N' side is modified to include foreign key of the relation on the 1 side.

04. Ans: (d)

Sol: Conceptual database design is done using E-R model

05. Ans: (d)

06. Ans: (b)

Sol: As Date of birth need not be changed, it is a stored attribute. Degree of a person can be composed, as he may have many degrees. Telephone number can be multi-valued, as one person can have many numbers. Name of dependent is a discriminator attribute.

07. Ans: (c)

Sol: All M-N relationships in E-R model are implemented in relational model as separate tables.

08. Ans: (b)

Sol:

09. Ans: (c)

Sol: The tuples present at a particular moment is called relation instance.

10. Ans: (c)

Sol: Cardinality is the number of tuples in a relation instance.

11. Ans: (c)

Sol: A database schema is a description of database.

A data model is a set of concepts used to describe database.

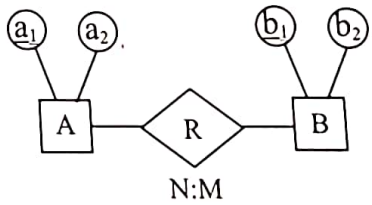
A database instance is a collection of data stored.

12. Ans: (b)

Sol: Relationship set can be merged with 'M' side of an entity set.

13. Ans: (c)

Sol:



The above ER model is represented as the following relations

A(a1, a2)

B (b1, b2)

R(a_1b_1) where a_1, b_1 are foreign keys of A and B.

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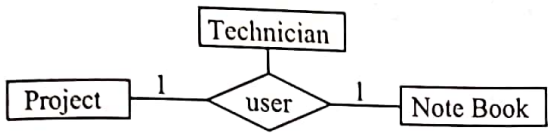
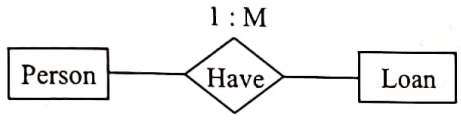
14. Ans: (c)

Sol:



15. Ans: (c)

Sol:



In Relational mode we represent the above situation with only two relations person and (Loan, Have).

16. Ans: (b)

17. Ans: (b)

Sol: A minimum cardinality of zero specifies partial participation.

18. Ans: (d)

Sol: No overlapping constraint because no employee can both be secretary or technician or an engineer and all these categories collectively includes employee.

19. Ans: (d)

Sol: As from left side, cardinality is 1:m and from right side is 1: m. Hence the cardinality is m : n

20. Ans: (d)

21. Ans: (a)

Sol: For example consider the following E–R diagram.

The above E–R model represents an Employee purchase policies for many dependents and a dependent is covered with policy by many employees.

22. Ans: (c)

Sol: P: A candidate key determines all the attributes of a relation.

Q: Subset of a candidate key may determine all the attributes of a relation.

R: A super key can determine all the attributes.

23. Ans: (a)

Sol: The relations in relational model are:

ER(a, c, b)

F(c, d)

G(a, c,e)

H(g, h)

S(a, c, g, f)

24. Ans: (a)

Sol: As entity set 'A' is the key to the relationship, the maximum number of tuples in relationship set is, the number of tuples in A.

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25. Ans: (c)

Sol: We get minimum of 5 tables.

26. Ans: (b)

Sol: Student table contains primary key of department and course as foreign key.

27. Ans: (b)

28. Ans: (b)

Sol: Degree of a person is composite of Basic degree, PG degree and other.

Date of birth can be stored attribute and which can't be changed.

Telephone number can be a multivalued attribute and can have more than one value.

Name of the dependent can be a discriminator attribute of the weak entity set.

29. Ans: (d)

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Chapter 2 Functional Dependencies

01. A relation R(ABCD) with dependencies A→BC, CD→B. The relation is decomposed into R_1(ABC) and R_2(BCD). Which of the following combination is correct?
(I) Loss less decomposition
(II) Lossy decomposition
(III) Dependency preserving
(IV) Not dependency preserving
(a) I and III (b) I and IV
(c) II and III (d) II and IV

02. Find the no. of candidate keys for relation R (A B C D E F) with fd set
F = {A → C, AB →D, B→D, C → E, E → A, D → B}
(a) 3 (b) 4 (c) 5 (d) 6

03. Consider two sets of functional dependencies F & G if F={A→C, AC→D, E→AD, E→H}, then the equivalent of G is
(a) G = {A→CD, E→AH}
(b) G = {A→CH, E→ADH}
(c) G = {A→CD, E→H}
(d) G = {A→AH, E→CH}

04. Suppose that we have the following four tuples in a relation S with three attributes ABC: (1, 2, 3) (4, 2, 3) (5, 3, 3,) (5, 3, 4) which of the following functional and multi valued dependencies does hold over relation 'S'.
1. B → C 2. AB → C
3. BC → A 4. AC → B

05. Consider the relation R= ABCDEG and F={AB→C, AC→B, AD→E, B→D, BC→A, E→G},
then the decomposition
{ABC, ACDE, ADG}
(a) is lossless and not dependency preserving
(b) is not loss less and dependency preserving
(c) is loss less and dependency preserving
(d) is not loss less and not dependency preserving

06. R(A, B, C, D) with FD's
F {A → B, A → C, A → D}
Decomposed into
R1(A, B, D) with FD's
F1 {A → B, A → D} and
R2 (B, C) with FD's
F2 = { }
Then find which statement is true:
(a) This is not dependency – preserving relation
(b) This is dependency –preserving relation
(c) This is partially dependency preserving relation
(d) This is non-decomposable relation with full dependency preserving

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07. The Relation R(ABCDEF) and the FDset F2{A→C, BC→D, BE→F, D→E} is decomposed into two tables R_1(ABCD) and R_2(ABEF).

Which of the following is a true statement?

(a) The decomposition lossless Join and dependency preserving.
(b) The decomposition is lossless Join but not dependency preserving
(c) The decomposition is dependency preserving and lossy
(d) The decomposition is not dependency preserving and lossy

08. Find out the number of candidates keys for the table R(ABCDEFG) and Fd set
F = {AB → CDEFG, D→B, C→ AD, E → F, EF→ D, G → EF, F→ E}
(a) 5 (b) 4 (c) 6 (d) 7

09. A functional dependency set
F = {A→B, BC→E, ED→A, EF→G, E→F}.
Find out the closure of (AC)
(a) {A, B, C, D, E, F, G}
(b) {A, B, C, D, E, F}
(c) {A, B, C, D, E, G}
(d) {A, B, C, E, F, G}

10. **Assertion[a]:** A Relation R(ABC) is having 3 rows and ($\Pi_{r1}(R) \times \Pi_{r2}(R)$) results in 3 rows.
Reason [r]: Natural Join joins two tables based on all common columns with equality conditions.
(a) Both (a) and (r) are true and (r) is the correct reason for (a).
(b) Both (a) and (r) are true but (r) is not the correct reason for (a).
(c) Both (a) and (r) are false.
(d) (a) is true but (r) is false.

11. A relation R(ABC) is having following 4 tuples : (1,2,3), (4,2,3), (5,3,3) and (2,4,4). Which of the following dependencies can you infer doesn't hold over relation R?
(a) A → B (b) B → C
(c) AB → C (d) C → B

12. A relation R(ABC) is having following tuples (S_1, P_1, J_2), (S_1, P_2, J_1), (S_2, P_1, J_1) and (S_1, P_1, J_1). The above relation R is decomposed into two relation R_1(AB) and R_2(BC). The effect of joining R_1 and R_2 over B will result in which of the following spurious tuple.
(a) (S_2, P_2, J_1) (b) (S_1, P_2, J_1)
(c) (S_2, P_1, J_2) (d) (S_2, P_2, J_2)

13. Consider the following sets of functional dependencies:
F = {A→C, AC→D, E→AD, E→H} and
G = {A→CD, E→AH}.
Which of the following is true?
(a) F covers G
(b) G covers F
(c) F and G are equivalent
(d) none of the above

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14. A relation R(ABC) is having the tuples (1, 2, 1), (1, 2, 2), (1, 3, 1) and (2, 3, 2). Which of the following functional dependency holds good?

(a) A → BC
(b) AC → B
(c) AB → C
(d) BC → A

15. Find what FD is violated by the Relation R = { } i.e. empty relation

(a) All FDs
(b) Does not violate FDs
(c) Cannot say
(d) None of the above

16. Under what condition, a table may have partial dependencies

(a) If table consists one prime attribute
(b) If table consists only one attribute
(c) If table consists only two attributes
(d) If table consists two prime attributes

17. Which one of the following functional dependencies are satisfied by all relations in a Database?

(a) Completely non trivial FDs
(b) Non trivial FDs
(c) Trivial FDs
(d) None

18.

	A	B	
t_1			
t_2			

If t_1 and t_2 disagree at A then what about B to hold the FD A→B, pick the appropriate answer.

(a) They must disagree in B
(b) They must agree in B
(c) They need not disagree in B
(d) They may agree or disagree in B

19. State under what condition in the following relation, the FD BC → D is violated?

R =

A	B	C	D	E
a	2	3	4	5
a	2	3	6	5
a	2	3	6	6
a	2	3	4	

(a) If a = 2
(b) If a = 3
(c) For all values of a
(d) For none of the values of A

20. Find what dependency may not hold on the following relation?

A	B	C	D
a_1	b_1	c_1	d_1
a_1	b_1	c_2	d_2
a_2	b_1	c_1	d_3
a_2	b_1	c_3	d_4

(a) A → B
(b) D → ABC
(c) C → D
(d) D → B

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21. Consider the following FDs for the relation R=ABCDEFGHIJ and use FDs: AB → C, A → DE, B → F, F → GH, D →I J.

If 'R' is split into ABC, ADE, BF, FGH, DIJ then this decomposition is.

(a) Lossy and dependency preserving
(b) Lossless and dependency preserving
(c) Lossy and not dependency preserving
(d) Lossy and not dependency preserving

22. Suppose you are given a relation R(ABCD) with the following sets of FDs, assuming they are the only dependencies that hold for R.

A → B, B → C, C → D; is decomposed into AB & ACD. Describe the decomposition.

(a) It is lossy and not preserving dependencies
(b) It is lossless and preserving dependencies
(c) It is lossless and not preserving dependencies
(d) It is lossy and preserving dependencies

Common Data Question for Q 23 & 24:

Consider relation R(ABCDEFGH)

FDs are AB → CEFGH, A→ D, F → G, FB → H, HBC → ADEFG, FBC → ADE

23. Find the key for the relation.

(a) HB (b) FB
(c) AB (d) AC

24. Based on the key found in 23, find the Partial dependency

(a) FB → H (b) F → G
(c) AB → CEFGH (d) A → D

25. What are essential properties of Functional dependencies (FD)?

(a) There is a one to one Relationship between attributes in FDs
(b) FDs must be defined on schema
(c) FDs must be non-trival
(d) All of the above

26. Consider a relation with five attributes ABCDE. You are given the following dependencies.

A → B, BC → E, ED → A. Find the key(s) for the relation.

(a) AED
(b) CDE
(c) Both (a) and (b)
(d) Neither (a) nor (b)

27. Suppose that we have the following three tuples in a legal instance of a relation schema with three attributes ABC as (1,2,3), (4,2,3) and (5,3,3). Then which of the following dependencies can you infer does not hold over schema

(a) A → B (b) BC → A
(c) B → C (d) All the above

28. Suppose that we decompose the schema R= (ABCDE) into ABC and ADE. Find the characteristics of the decomposition if the following set of Fds holds

A → BC CD → E B → D E → A

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(a) Lossy and dependency preserving decomposition

(b) Lossy and not dependency preserving decomposition.

(c) Lossless and not dependency preserving decomposition

(d) Lossless and dependency preserving decomposition

29. Consider the following set of functional dependencies on the relation (ABC),

$\{A \to B,\ AB \to C, A \to BC, B \to C\}$.

Find the canonical cover for the above FD set

(a) $\{A \to BC, B \to C\}$

(b) $\{A \to BC, AB \to C\}$

(c) $\{A \to BC, A \to B\}$

(d) $\{A \to B, B \to C\}$

Common Data Questions 30& 31:

Suppose that we have two sets of FDs, X and Y

$X = \{B \to CD, AD \to E, B \to A\}$

$Y = \{B \to CDE, B \to ABC, AD \to E, E \to A\}$

30. Find the equivalences of X and Y.

(a) They are equivalent

(b) They are not equivalent

(c) We cannot say

(d) None of the above

31. What makes X and Y are equivalent or not equivalent?

(a) Adding $B \to ABC$ to X makes them equivalent

(b) Removing $E \to A$ from Y makes X and Y are equivalent

(c) Removing $B \to ABC$ from Y makes X and Y are equivalent

(d) We need not add or remove anything from X or Y to make them equivalent

32. Consider relation R(ABCDEFGH).

FDs are

$AB \to CEFGH, A \to D, F \to G, FB \to H$

$HBC \to ADEFG, FBC \to ADE$

Find the Partial dependency.

(a) $FB \to H$ (b) $F \to G$

(c) $AB \to CEFGH$ (d) $A \to D$

33. Consider a relation with five attributes ABCDEG. You are given the following dependencies. $AB \to C$, $AC \to B$, $AD \to E$, $B \to D$, $BC \to A$, $E \to G$. If relation is decomposed into AB, BC, ABDE, EG, then find the characteristics of this decomposition.

(a) Not lossless, not preserve FDs.

(b) Not lossless, preserve FDs.

(c) Lossless, preserve FDs.

(d) Lossless, not preserve FDs.

34. The relation R(ABCDEF) with the set of Fds

$F = \{A \to CE, B \to D, C \to AD, BD \to EF\}$.

Find the closure of AB

(a) ABCE (b) ACED

(c) ABCDE (d) None

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35. Consider two dependency sets F and G,

$F = \{A \to B, AB \to C, D \to AC, D \to E\}$

$G = \{A \to BC, D \to AB\}$

(a) F covers G only
(b) G covers F only
(c) F & G are equal
(d) can't say

36. Consider the following two sets of FDs:

1. $A \to C, E \to AD, C \to D, E \to H,$
2. $A \to CD, E \to AH, D \to C,$

Which of the above FDs makes these two sets are not equivalent?

(a) $C \to D$
(b) $E \to AH$ in set 2, $C \to D$ in set 1
(c) $D \to C$ in set 2 and $C \to D$ in set 1
(d) $A \to C$ in set 1 and $C \to D$ in set 2

37. Find the irreducible set for the following Fds

$A \to BC, ABE \to CDGH,$
$C \to GD, D \to G, E \to F$

(a) $A \to BC$, $ABE \to CDGH$, $C \to GD$, $D \to G$, $E \to F$
(b) $A \to BC$, $AE \to H$, $C \to D$, $D \to G$, $E \to F$
(c) $A \to BC$, $AB \to CGH$, $C \to G$, $D \to G$, $G \to F$
(d) $A \to BC$, $BE \to CDGH$, $C \to GD$, $D \to G$, $G \to F$

Common data for Q38, Q39:

Consider R = ABCDEFGHIJK, with Functional dependencies

$ABD \to E, AB \to G, B \to F, C \to J,$
$CJ \to I, G \to H.$

38. What is the key for the relation?

(a) ABD (b) ABDK
(c) ABCD (d) None of the above

39. Which one of the following FD can be derived from the above table R?

(a) $A \to BC$ (b) $C \to H$
(c) $AC \to I$ (d) $AGH \to F$

40. Functional dependencies (F) on relational Schema R= (ABCDE) are $A \to BC$, $CD \to E$, $B \to D$, $E \to A$ Compute the canonical cover F_c

(a) $A \to B$, $CD \to E$, $B \to D$, $E \to A$
(b) $A \to BC$, $CD \to E$, $B \to D$, $E \to A$
(c) $A \to BC$, $D \to E$, $B \to D$, $E \to A$
(d) $A \to BC$, $C \to E$, $B \to D$, $E \to A$

41. Which one of the following instances of R(ABCDE) not violates $BC \to D$?

(a) R=(a,2,3,4,5)(2,a,3,4,5)(a,2,3,6,5) if a = 2.
(b) R = (a,2,3,4,5) (2,a,3,4,5) (a,2,3,6,5) if a = 3.
(c) R = (a,2,3,4,5) (2,a,3,4,5) (a,2,3,a,5) if a = 4.
(d) R = (a,2,3,4,5) (2,a,3,4,5) (a,2,3,6,5) if a = any value.

42. Which of the following FD sets generates maximum possible number of superkeys for the Relation R(A, B, C)?

(a) $A \to B, B \to C$
(b) $A \to B, B \to C, C \to A$
(c) $AB \to C, BC \to A, AC \to B$
(d) None of these

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43. R(A, B, C, D) is a relation. Which of the following does not have a lossless join, dependency preserving BCNF decomposition?
(a) A→B, B→C, C→D
(b) A→B, B→A, AC→D
(c) AB→C, C→A, C→D
(d) Both (b) and (c)

44. A table with 3 attributes consists 4 rows (1, 2, 3), (5, 2, 3), (6, 3, 3), (9, 2, 8).
Which of the following dependency holds well?
(a) B → C
(b) BC → A
(c) A → C
(d) None

45. Set of functional dependencies for R (ABCD) is AB → C, AB → D, C → A, D → B, total number of candidate keys for the relation is
(a) 1
(b) 4
(c) 3
(d) 2

46. If R= (ABCDEHG) with FDs = AD → E, AB→C, B→D, AC→B, E→G, BC→A then what is the key for the relation?
(a) AC
(b) ACEH
(c) BD
(d) BEGD

47. Assume we have three instances of a relation R with three attributes (A, B, C), they are (1, 2, 3), (4, 2, 3), (5, 3, 3). Which of the following dependencies does not hold over schema R?
(a) B→C
(b) A→B
(c) BC→A
(d) AB→C

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Solutions

01. Ans: (c)

Sol: $A \rightarrow BC$ is in R_1 (ABC) and $CD \rightarrow B$ is in R_2(BCD).

02. Ans: (d)

Sol: ck: ABF, EBF, CBF, ADF, EDF, CDF.

03. Ans: (a)

Sol: 'C' can be deleted from $AC \rightarrow D$

'D' can be deleted from $E \rightarrow AD$.

04. Ans: (d)

Sol: Only $AC \rightarrow B$ dependency satisfying on the given relation.

05. Ans: (a)

Sol: $B \rightarrow D$ and $E \rightarrow G$ is lost

06. Ans: (a)

Sol: $A \rightarrow C$ dependency is lost.

07. Ans: (b)

Sol: $D \rightarrow E$ dependency is lost.

08. Ans: (c)

Sol: Candidate keys: AB, AD, AF, AG, C, AE

09. Ans: (d)

Sol : $AC^+ = \{A, C, B, E, F, G\}$

10. Ans: (a)

Sol: The decomposition is lossless as common attributes is key in either of the relations.

11. Ans: (d)

Sol : Only $C \rightarrow B$ does not hold over R.

12. Ans: (c)

Sol:

R_1	R_2	$R_1 \bowtie R_2$
AB	BC	ABC
S_1P_1	P_1J_2	$S_1P_1J_2$
S_1P_2	P_2J_1	$S_1P_1J_1$
S_2P_1	P_1J_1	$S_1P_2J_1$
		$S_2P_1J_2$ → spurious
		$S_2P_1J_1$

13. Ans: (c)

Sol : F and G are said to be equivalent iff both F and G covers each others.

14. Ans: (d)

Sol: Only $BC \rightarrow A$ holds over R.

15. Ans: (b)

Sol: Empty Relation do not violate any FD's.

16. Ans: (d)

Sol: Partial Dependency: part of key → nonkey.

17. Ans: (c)

Sol: Trivial FD's are satisfied by all relations, in a database.

18. Ans: (d)

Sol: If t_1 and t_2 agree on A then, they must also agree on B, but not vice versa.

19. Ans: (c)

Sol: $BC \rightarrow D$ not depends on attributes A.

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20. Ans: (c)

Sol: C→D doesnot hold over R.

21. Ans: (b)

Sol: All the dependencies are on the decomposed relations and it is lossless decomposition.

22. Ans: (c)

Sol: B → C dependency is lost.

23. Ans: (c)

Sol: AB^+ contains all the attributes of a relation.

24. Ans: (d)

Sol: Partial FD: part of key → nonkey.

25. Ans: (d)

26. Ans: (b)

Sol: Candidate keys for R is ACD, BCD and ECD.

27. Ans: (b)

Sol: BC→A doesnot hold over R.

28. Ans: (c)

Sol: Both CD → E and B → D dependencies lost.

29. Ans: (d)

Sol: 'B' can be deleted from AB → C.

'C' can be deleted from A → BC

30. Ans: (b)

Sol: E → A of Y is not covered by X.

31. Ans: (b)

Sol: Only E→A of Y is not covered by X; Removing it makes both X and Y are equivalent.

32. Ans: (d)

Sol: AB is key for relation R and A→D is a partial dependency.

33. Ans: (a)

Sol: The decomposition is both lossy and not dependency preserve.

34. Ans: (d)

Sol: $AB^+ = \{ABCDEF\}$

35. Ans: (a)

Sol: G not covers the dependency D → E of F.

36. Ans: (c) **37. Ans: (b)**

38. Ans: (d)

Sol: Candidate key: ABCDK.

39. Ans: (c)

Sol: As AC^+ contains I, then AC → I possible.

40. Ans: (b)

Sol: There is no dependency which is redundant.

41. Ans: (c)

42. Ans: (b)

Sol: (a) 4 sk: A, AB, AC, ABC

(b) 7 sk: A, B, C, AB, AC, BC, ABC.

(c) 4 sk: AB, AC, BC, ABC.

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43. Ans: (d)

Sol: In BCNF decomposition of both options (b) and (c), AC→D and AB→C dependencies will lost.

44. Ans: (c)

Sol: Only A→C holds well.

45. Ans: (b)

Sol: Candidate keys: AB, CB, AD, CD.

46. Ans: (b)

Sol: $ACEH^+$ contains all the attributes of R.

47. Ans: (c)

Sol: Only BC→A does not hold over R.

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Chapter 3 Normalization

01. Consider a relation with (emp id, speciality and manager id). The following business rules hold for the above relation.

(i) employee may have many specifications

(ii) each speciality has many managers

(iii) employee has only one manager for each speciality

(iv) each manager has only one speciality

Find out the normal form of the above relation

(**Note:** First find functional dependencies)

(a) 1NF (b) 2NF

(c) 3NF (d) BCNF

02. A relation R(ABCD) is in 3NF but not in BCNF. Which of the following dependency set is suitable for above statement?

(a) {AB → CD, A →C, D → B}

(b) {AB → CD, C → DA}

(c) {A → BCD, B →CD, C → D}

(d) {AB → CD, C →A, D → B}

03. Consider a relation R(ABCDE) with the following dependency sets. Which of the below alternative can be decomposed in to BCNF without violating dependency preservation?

(a) {ABC → DE, DE →C }

(b) {AB → C, ABD → E, E → D}

(c) {ABC → DE, D → B, E → C}

(d) {ABC → DE, D → EA, A → D}

04. A relation R (ABCDEF) with fd set F = {AB → CDE, CD → E, E → C}. Which of the following statement is false?

(a) The above relation can be decomposed into 2NF with dependency preservation.

(b) The above relation can be decomposed into 3NF with dependency preservation.

(c) The above relation can be decomposed into BCNF with dependency preservation.

(d) All of the above

05. Consider the relation

R={A,B,C,D,E,F,G,H,I,J} and set of FDs are F=A,B→C, A→D,E, B→F, F→G,H, D→I,J , if we decompose R into 3NF, then possible tables are

(a) {D, I, J}, {A, D, E}, {F, G, H}, {B, F}, {A, B, C}

(b) {D, I, J}, {A, C, E}, {F, G, H}, {B, F}, {A, D, C}

(c) {F, G, H} {D, I, J}, {A, D, E, B, F}, {A, B, C}

(d) None of the above

06. Consider a relation R(ABCDEFG) with the following functional dependency Set F={AB→CDEF, C→ADE, D→EBF, F→BA, BE→AF}

Find out the normal form of above table

(a) 1NF (b) 2NF

(c) 3NF (d) BCNF

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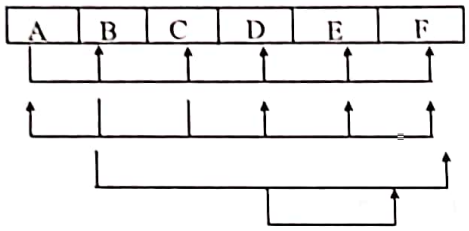
07. The best normal form for the instance is



(a) 1NF (b) 2NF
(c) 3NF (d) BCNF

08. R(ABCDE) and the set of Fds on R given by $F = \{AB \rightarrow CD, ABC \rightarrow E, C \rightarrow E\}$.
What is the normal form of R?
(a) 1NF (b) 2NF
(c) 3NF (d) BCNF

09. A Relation R is in 3NF but not in BCNF.
Which of the following is a false statement?
(a) The relation R will have insertion anamoly
(b) The relation R may have updation anamoly
(c) The relation R may have deletion anamoly
(d) The relation R will not have data redundancy.

10. **Assertion[a]:** A relation R(ABCDE) with FD set $F = \{A \rightarrow B, B \rightarrow C, D \rightarrow E, C \rightarrow D, C \rightarrow A\}$ is decomposed into BCNF as R_1(ABCD) and R_2(DE).
Reason[r]: R_1(ABCD) is in BCNF and R_2 (DE) is in BCNF
Choose:
(a) Both (a) and (r) are true and (r) is the correct reason for (a).
(b) Both (a) and (r) are true but (r) is not the correct reason for (a).
(c) Both (a) and (r) are false.
(d) (a) is true but (r) is false.

11. **Assertion [a]:** A relation R(ABCD) and FD set $F = \{AB \rightarrow CD, B \rightarrow C, C \rightarrow D\}$ is decomposed into BCNF as R_1(AB), R_2(BC) and R_3(CD).
Reason [r]: R_1, R_2 and R_3 decomposition is lossless.
Choose:
(a) Both (a) and (r) are true and (r) is the correct reason for (a).
(b) Both (a) and (r) are true but (r) is not the correct reason for (a).
(c) Both (a) and (r) are false.
(d) (a) is true but (r) is false.

12. Find out set of FDs for the relation schema R(A,B,C,D) with primary key AB under which R is in 2NF but not in 3NF
(a) $\{AB \rightarrow CD, A \rightarrow C, C \rightarrow D\}$
(b) $\{AB \rightarrow CD, B \rightarrow C, C \rightarrow B, A \rightarrow D\}$
(c) $\{AB \rightarrow CD, C \rightarrow D, DB \rightarrow AC\}$
(d) $\{AB \rightarrow CD, BC \rightarrow D\}$

13. Business Rules:
1. An employee may work in many departments
2. Each employee has a unique employee number

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3. Each department has many managers
4. An employee has only one manager for each department
5. Each manager can manage only one department
6. Each employee has only one Name

The given table is in which normal form?

(a) 1NF (b) 2NF
(c) 3NF (d) BCNF

Data for 14 and 15 are given below. Solve the problems and choose correct answer:

The Given table R(ABCDEF) and FD set F = {AB → CDEF, C→A, D→B, C → D, E → F, B → E}

14. Find out the normal form of above relation R
(a) 1NF (b) 2NF
(c) 3NF (d) BCNF

15. Decompose the above relation R into 3NF.
(a) (ADC), (DBEF)
(b) (ABCD), (BEF)
(c) (ADC), (DB), (BE), (EF)
(d) (ABCD), (BE), (EF)

16. A relation R(ABCDEF) and the functional Dependency set F = {AB → CDEF, B → F, A → DE, C → A, E → B} Find out the normal form of the above relation R
(a) 1 NF (b) 2NF
(c) 3 NF (d) BCNF

17. If X → A is FD on a relation and it is not allowed in 3 NF, if
1. X is a proper subset of some key
2. X is a not a proper subset of any key
3. X is a key
4. A is a part of some key
(a) 1 & 3 are correct
(b) 1 & 2 are correct
(c) 3 & 4 are correct
(d) 1 & 2 are not correct

Common Data for Q18, Q19 & Q20 is given below.

Consider the relation for published books Relation (ABCDEF)
FDs: A → FC, C → D, B → E

18. Find the key of R
(a) AC (b) AB (c) BC (d) DC

19. Find the 2NF relations
(a) ACDF, AE (b) ACDF, BE, AB
(c) BE, AB (d) ACD, BE, AB

20. Find the 3NF relations
(a) ACDF, BE, AB
(b) ACDF, BE, AB, CD
(c) CD, ACF, BE, AB
(d) None

21. Match the following with most appropriate type of attributes:

List – I
(P) 1NF (Q) 2NF
(R) BCNF (S) 3NF

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List – II

1. Transitive dependencies
2. Partial Dependencies
3. Unique rows
4. Candidate keys

Codes:

(a) P – 4, Q – 3, R – 2, S – 1
(b) P – 4, Q – 2, R – 3, S – 1
(c) P – 4, Q – 1, R – 2, S – 3
(d) P – 3, Q – 2, R – 4, S – 1

For Question No. 22 there are two statements Assertion (a) and Reason (r).

22. **Assertion (A):** Table with two attributes is in 3NF.

Reason (R): Table with two attributes is free from partial and transitive dependencies.

(a) Both (a) and (r) are true and (r) is the correct reason for (a).
(b) Both (a) and (r) are true and (r) is not the correct reason for (a).
(c) Both (a) and (r) are false.
(d) (a) is true but (r) is false.

Common data for Q23 & Q24.

Consider a relation with seven attributes ABCDEGH. You are given the following dependencies.

AB → C, AC → B, AD → E, B → D, BC → A, E → G

23. What is the key?

(a) ACE (b) ACH
(c) ACEH (d) It cannot be identified

24. Based on the key identified in Q23, what is the normal form that this table best satisfies?

(a) 2 NF (b) 3 NF
(c) BCNF (d) 1 NF

25. Pick up the ***incorrect*** statements of the following:

P: 2NF (Normal form) deals with transitive dependencies.
Q: BCNF deals with candidate keys.
R: X→Y is allowed in 3NF, if X is a super key or Y is part of the key.
S: If table is empty, it never satisfy any Functional dependency.
T: 1NF alone is mandatory normal form, rest of them are optional.
U: If ER diagram is converted into tables, then these tables must be evaluated for 4NF and 5NF.

(a) P, Q, U (b) Q, R, T
(c) P, S, U (d) R, S, U

Common Data for Q26 & Q27:

R = ABCDEFG, FDs = BC→E, A→F, A→G, C → D, F → G, BCD → A.

26. What is the key for the above relation?

(a) BC (b) BD
(c) BCD (d) A

27. What are BCNF tables?

(a) CD, AF, FG, BAE
(b) CD, AF, FD, BCAE
(c) CD, AF, FG, BCAEF
(d) CD, AF, FG, BCAE

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28. Relation R is decomposed using a set of functional dependencies F and relation S is decomposed using another set of functional dependencies G. One decomposition is definitely BCNF, the other is definitely 3NF, but it is not known which is which. To make guaranteed identification, which one of the following tests should be used on the decompositions?(Assume that the closures of F and G are available)

(a) Dependency-preservation
(b) Lossless-join
(c) BCNF decomposition
(d) 3NF decomposition

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Solutions

01. Ans: (c)

Sol: The functional dependencies possible are:

empid, speciality → managerid

managerid → speciality

Candidate keys: (empid, speciality) and (empid, managerid). The relation is in 3 NF.

02. Ans: (d)

Sol: (a) 1NF (b) 2NF

(c) 2NF (d) 3NF

03. Ans: (d)

Sol: Option(d) is decomposed into BCNF relations as R_1(AD) R_2(ADE) and R_3(ABCD).

04. Ans: (b)

Sol: 3NF decomposed relations are R_1(ABCD), R_2(CDE).

05. Ans: (a)

Sol: Key of the above relation is AB.

R is in 1NF.

BCNF relations are (ABC), (ADE), (BF), (FGH), (DIJ).

06. Ans: (d)

Sol: Keys of the relations are AB, C, D, F, BE hence the relation is in BCNF.

07. Ans: (a)

Sol: Relation contains PFD: B → F.

08. Ans: (b)

Sol: Relation contains TD: C → E.

09. Ans: (d)

Sol: A relation is in 3NF but not in BCNF, have the problem of prime transitivity and have insertion, updation and deletion anomalies.

10. Ans: (a)

Sol: D → E is Transitive dependency, after decomposition into 3 NF. The relations are also in BCNF.

11. Ans: (b)

Sol: Decomposition, causing loss of FD: AB → CD.

12. Ans: (d)

Sol: BC → D is Transitive FD.

13. Ans: (b)

Sol: key for the table is empNo.

Business rules 4 and 5 representing the Transitive dependencies, and the relation is in 2 NF.

14. Ans: (a)

Sol: CK: AB, CB, AD, CD.

B → E is Partial Functional Dependency.

R is in 1 NF.

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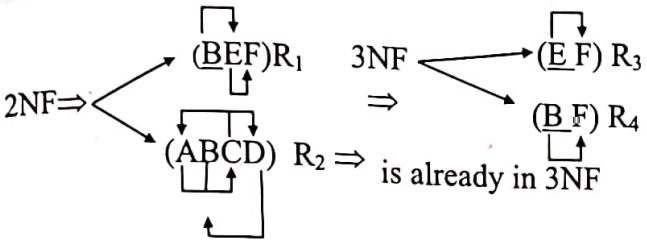
15. Ans: (d)

Sol: Key of the relation is AB and C.

B→E is partial dependency, relation is in 1NF



3NF relations are (ABCD), (BE) and (EF).

16. Ans: (a)

Sol: B → F is PFD.

17. Ans: (b)

Sol: 1 represents Partial FD and 2 represents T.D

18. Ans: (b)

Sol: AB^+ = ABCDEF.

19. Ans: (b)

Sol: A→FC and B→E are partial dependencies. 2NF relations are (ACDF), (BE) and (AB).

20. Ans: (c)

Sol: 3NF relations are (AFC), (CD), (BE), (AB). C→D is transitive dependency.

21. Ans: (d)

22. Ans: (a)

23. Ans: (b)

Sol: ACH^+ = A, C, H, B, D, E, G

24. Ans: (d)

Sol: E → G is Partial F.D.

25. Ans: (c)

26. Ans: (c)

Sol: BCD^+ = B C D A F G E

27. Ans: (d)

Sol: BC→E is partial dependency, relation is in 1NF then BCNF relations are (CD), (AF), (FG), (ABCE).

28. Ans: (c)

Sol: A Relation in BCNF is also in 3NF. But a relation in 3NF need not be in BCNF.

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Chapter 4 Structured Query Language (SQL)

01. The tables generated on compilation of data definition language are stored in _____.
(a) data abstraction (b) data file
(c) data dictionary (d) meta data

02. [(Select eno from emp where dept.no = 10) UNION (Select eno from emp where deptno= 20)] is query 1, (Select eno from emp where deptno = 10 or deptno = 20) is query 2.

I. Query 1 and Query 2 gives same no. of rows.
II. Query 1 and Query 2 gives same no. of rows if there are no duplicates in eno.
III. The output of query 1 and query 2 look alike row by row if eno is a primary key for the relation emp.

(a) I only (b) II only
(c) III only (d) I & III

03. Identify the correct statement regarding 'view'.
(a) View provides automatic security for hidden data
(b) Views allow the same data to be seen by different users in different ways at the same time
(c) Views can provide logical data independence
(d) All of the above

04. What techniques are used to retrieve data from more than one table in a single SQL statement.
(a) joins (b) union
(c) nested selects (d) all the above

05. What is unsafe query?
(a) The query that has zero results
(b) The query that has inconsistent results
(c) The query that has infinite results
(d) The query that cannot return results.

06. Consider the join of a relation R with a relation S. If R has m tuples and S has n tuples. Then the maximum and minimum sizes of the join respectively are
(a) m+n and 0 (b) mn and 0
(c) m+n and (m – n) (d) mn and m+m

07. Sailors

sid	sname	rating	age

All the columns in the above table are defined as NOT NULL. Consider the following query: Find the names of sailors with a higher rating than all the sailors with age less than 21.

i. Select sname From Sailors S
where not exists (Select * From Sailors S2
where S2.age <21 and S.rating>= S2.rating)

ii. Select sname From Sailors
where rating > any (Select rating From Sailors where age < 21)

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(a) Query (i) & Query (ii) both queries the required results.

(b) (i) & (ii) both will not give required results

(c) Query (i) gives the required results but Query (ii) doesn't.

(d) Query (ii) gives the required results but Query (i) doesn't

08. **Sailor**

Sid	Sname	age

Reserves

Sid	Bid	date

Boat

bid	bname	colour

i. Select bid, count(*) From boat B, Reserves R Where R.bid = B.bid and colour = 'Red' Group By B.bid

ii. Select B.bid, count(*) From boat B, Reserves R Where B.bid = R.bid Group By B.bid having B.colour = 'Red'

iii. Select B.bid, count(*) From boat B, Reserves R Where B.bid = R.bid Group By B.bid, B.colour having B.colour ='Red'

Which of the following is a true statement?

(a) Query (i) and Query (ii) gives the same result

(b) Query (ii) and Query (iii) gives same result

(c) Query (iii) results an error

(d) Query (i) and Query (iii) gives the same result

09. Consider the following table structures.

Customer

cname	st	City

Deposit

cname	st	city

Borrow

lno	cname	Amt	Bname

Query (i): (Πcname, st(Customer |X| (Deposit |X| Borrow))).

Query (ii): Select C.cname, st From Customer C, Deposit D, Borrow B Where C.cname = d.cname and d.cname = b.cname

Query (iii): Select cname, st From Customer Where cname in (Select cname From Deposit d where exists

(Select * From Borrow b where b.cname = d.cname and b.bname = d.bname))

Which of the following is true statement?

(a) Query (i) & Query (iii) gives the same result

(b) Query (ii) prints the cname, st who has got a deposit and a loan

(c) Query (i) and Query (ii) gives same result

(d) Query (iii) prints the cname, st who has got a deposit and a loan in the same branch.

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10. **Assertion [a]:** A Relation R(AB) with tuple (1, NULL), (2, 1), (3, 2) and the execution of query: Select count (*) from R as R1 and R as R2 where R1.A>R2.B will result in value 1.
Reason [r]: Where clause filters the rows based on conditions in the where clause.
Choose
(a) Both (a) and (r) are true and (r) is the correct reason for (a).
(b) Both (a) and (r) are true but (r) is not the correct reason for (a).
(c) Both (a) and (r) are false.
(d) (a) is true but (r) is false.

11. Match the Following:
P: The database manipulation language is a language that allow modification of conceptual schema
Q: The data catalog stores description of database structure and constraints
R: A data catalog stores metadata
S: Transaction management is not a function of DBA
T: A language you can use to schemas is called data definition language

List - II
1. True
2. False
(a) P-1, Q-2, R-1, S-2, T-2
(b) P-1, Q-1, R-1, S-1, T-2
(c) P-2, Q-1, R-1, S-2, T-1
(d) P-2, Q-2, R-1, S-2, T-1

12. SELECT Name, Trainer FROM ACE WHERE Trainer IN (SELECT TRAINER FROM ACE WHERE Name = 'Ram' OR Name = 'Ravi')
The query results
(a) The name and trainer of either client Ram or Ravi.
(b) The name and trainer of everyone who has the same trainer as either Ram or Ravi.
(c) The name and trainer of everyone who has the same trainer as Ram and Ravi.
(d) None

13. Consider the table:
EMP

eno	ename	sal	job	Deptno

Query: Select deptno, count(*) From EMP
Group By deptno
Having job = 'manager' and Count(*) > 2;
Which of the following is correct statement?
(a) The above query prints department no. and no. of employees in each department in which more than 2 managers are working.
(b) The above query prints department no. and no. of managers in each department in which more than 2 managers are working.
(c) The above query prints department no. and no. of managers in each department in which more than 2 employees are working.
(d) The above query gives an error.

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14. Consider intersection of a relation R_1 with a relation R_2. If R_1 has n_1 tuples and R_2 has n_2 tuples. Where $n_2 >> n_1$, then the maximum and minimum possible sizes of the operation are

(a) n_1,0 (b) n_2, 0

(c) 0, n_1 (d) 0, n_2

15. Consider the following table:

empno	specialization
321	Electrical
322	IT
323	CSE
324	Chemical
325	Communication
326	Electrical
350	CSE
351	CSE

Select e1.empno, e2.empno
From Employee e1, Employee e2,
Where e1.specialization = e2.specialization
and e1.empno > e2.empno

What this query returns?

(a) Produces empno having the same specialization

(b) Produces all pairs of specialization having the same empno

(c) Produces all pairs of empno having the same specialization

(d) Produces empno, specialization having the same specialization

16. Consider the SQL query:

select *p.a*1
from *p*, *r*1, *r*2
where *p.a*1 = *r*1.*a*1 or *p.a*1 = *r*2.*a*1

Under what conditions does the preceding query select values of *p.a*1 that are either in *r*1 or in *r*2?

(a) If r1 and r2 are empty

(b) If both *r1* and *r2* are non-empty

(c) If either *r1* or *r2* is empty

(d) If either *r1 or r2* are non-empty

17. Select * from students where name like 'A%'; find the equivalent statement.

(a) Select * from students where name >='A';

(b) Select * from students where name >='A' or name <='B';

(c) Select * from students where name >='A' and name <='B';

(d) Select * from students where name >='A' and name <'B';

18. Consider a relation

Employees (empno, first_name, last_name, total_sales).

The query

SELECT first_name, last_name, total_sales
FROM employees
WHERE total_sales >= ALL(SELECT total_sales FROM employees)
WHERE total_sales is NOT NULL);

Returns

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(a) List the names and total sales for the employees with the lowest TOTAL_SALES
(b) List the names and total sales for the employees with the highest TOTAL_SALES
(c) List the TOTAL_SALES for all employees.
(d) No rows are returned.

19. Consider the following tables:
EMPLOYEE (Fname, Lname, Ssn, Bdate, Address, Sex, Salary, Superssn, dno)
DEPARTMENT(dname, dnumber, mgrssn, mgrstartdate)DEPENDENT(Essn, dependent_name, Sex, Bdate, Relationship)
WORKS_ON (Essn, Pno, hours)
PROJECT (Pname, Pnumber, Plocation, dnum)
DEPT_LOCATIONS(Dnumber, Dlocation)
To retrieve the name of each employee who works on all the projects controlled by department number 5 which one of the following options are correct?

(a) SELECT LNAME, FNAME FROM EMPLOYEE WHERE NOT EXISTS (SELECT * FROM WORKS_ON B WHERE (B.PNO IN (SELECT PNUMBER FROM PROJECT WHERE DNUM = 5)) AND NOT EXISTS (SELECT * FROM WORKS_ON C WHERE C.ESSN =SSN AND C.PNO = B.PNO));
(b) SELECT FNAME, LNAME FROM EMPLOYEE WHERE NOT EXISTS ((SELECT PNUMBER FROM PROJECT WHERE DNUM = 5) EXCEPT (SELECT PNO FROM WORKS_ON WHERE SSN = ESSN));
(c) SELECT FNAME, LNAME FROM EMPLOYEE WHERE ((SELECT PNO FROM WORKS_ON WHERE SSN = ESSN) CONTAINS (SELECT PNUMBER FROM PROJECT WHERE DNUM = 5));
(d) All are true

20. Consider the query
Select * from customers
Where rating > all (Select rating from customers where 1 = 2) Predict the output
(a) Returns all the rows from customers
(b) Returns no rows from customers
(c) Unpredictable output
(d) Cannot predict the output

21. Consider the schema:
Emp(eid, ename, age, salary)
Works (eid, did, hours_worked)
Dept (did, dname, budget, managerid)
'did' in Works table is the foreign key that references 'did' in Dept table

What option(s) for enforcing foreign key constraint when user attempts to delete a Dept tuple?
(a) Also delete all works tuples that refer to it
(b) Disallow the deletion of the *Dept* tuple if some *Works* tuple refers to it
(c) For every *Works* tuple that refers to it, set *did* field to some default department
(d) All of the above

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22. Select E.eid
From Employee E
Where E.salary= (Select max (E2.salary)
From Employee E2
Where E2.salary ≠ (select max (E3.salary) from Employees E3)
(a) It returns *eids* of employees who make highest salary
(b) It returns *eids* of employees who make second highest salary
(c) It returns *eids* of employees who make third highest salary
(d) It returns error message

23. Consider the schema:
Employee (eno, fname, lname)
Dependents (eno, name, age)

Find the appropriate output of the following query based on above schema.

Select fname, lname from employee E
Where exists (select * from dependent D
Where E.fname= D.name and E.eno=D.eno)

(a) List the names of all employees who have dependents
(b) List the names of all employees who do not have dependents
(c) List the names of employees who have dependent with the same name as themselves
(d) List the names of dependent who have employees with the same name as themselves

24. $\Pi_{AB}(r_1) \cup \Pi_{BC}(r_2)$, find the equivalent SQL query.
(a) Select r1.A, r2.B, r2.C from r1, r2 where r1.A=r2.A
(b) Select r1.A, r1.B, r1.C from r1, r2 where r1.A=r2.B
(c) Select r2.A, r2.B, r2.C from r1, r2 where r1.B=r2.A
(d) Select r1.A, r2.B, r2.C from r1, r2 where r1.B=r2.B

25. Consider the following SQL query and mention RA equivalent.
Select * from r1
Where (A, B, C) not in (Select * from r2)
Let R = (A, B, C) and r1 and r2 are relations on schema R.
(a) r2 – r1 (b) r1 / r2
(c) r2 / r1 (d) r1 – r2

26. Use the following tables for the below queries wherever table 1 and table 2 are used:

Table 1

T_1A	T_2B
a	aa
b	bb
c	cc

Table 2

T_1A	T_2B	T_2C
a	aa	a
b	bb	null

Select *
From Table1
Where T1A = all (Select T2B
From Table2)
Where T2B>='b')

How many number of rows will be there in the output?
(a) 1 (b) 2 (c) 3 (d) 0

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Consider the schema:

Flights(flno, from, to, distance, departs, arrives)

Aircraft (aid, aname, cruisingrange)

Certified (eid, aid)

Pilots (eid, ename, salary)

27. Select E.ename

From Aircraft A, Certified c, Pilots P

Where A.aid = C.aid and A.name='Boeing' and P.eid= C.eid

The above query Returns

(a) Find the *names* of pilots certified for Some aircraft
(b) Find the *names* of pilots certified for Bombay aircraft
(c) Find the *eids* of pilots certified for Boeing aircraft
(d) Find the *names* of pilots certified for Boeing aircraft

28. Select A.aid

From Aircraft A, Flights F

Where F.from = 'Bombay' and

F.to ='Hyderabad' and

A. cruisingrange > F.distance

The above query returns

(a) Finds aids of all aircraft that can be used on non stop flights from Bombay to Hyderabad.
(b) Finds aids of all flights that can be used on non stop flights from Bombay to Hyderabad.
(c) Finds aids of all aircraft that can be used on non stop flights from Hyderabad to Bombay.
(d) Finds aids of all aircraft that can be used on flights from Bombay to Hyderabad.

29. Select E.ename

From Aircraft A, Certified C, Pilots P

Where A.aid = C.aid and P.eid=C.eid an A.cruisingrange>3000 And P.eid not in (select C2.eid From Certified C2, Aircraft A2 Where C2.aid=A2.aid and

A2.aname = 'Boeing') ;

The above query returns

(a) Finds the names of pilots who can operate with a range greater than 3000 Km
(b) Finds the names of pilots but are not certified on any Boeing
(c) Finds the names of pilots who can operate with a range greater than 3000 Km, but are not certified on any Boeing
(d) Returns error

30. GUEST_ROSTER(NAME,TRAINER, ROOM, DISCOUNT, DEPARTURE, ARRIVAL)

SELECT Trainer, Count(name)

FROM GUEST_ROSTER GROUP BY Trainer

HAVING COUNT(name)>(SELECT COUNT(Name) FROM GUEST_ROSTER WHERE TRAINER = 'JULIO')

the query results

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(a) It gives the trainer and the no. of Guests trained by JULIO.

(b) It gives the TRAINER who gives training to more persons than JULIO and it also displays no. of persons.

(c) Both

(d) None

31. Consider the schema:

Flights (flno, from, to, distance, departs, arrives)

Aircraft (aid, aname, cruisingrange)

Certified (eid, aid)

Pilots (eid, ename, salary)

Select E.ename

From Aircraft A, Certified C, Pilots P

Where A.aid = C.aid and P.eid=C.eid and A.cruisingrange>3000

And P.eid not in (select C2.eid From Certified C2, Aircraft A2 Where C2.aid=A2.aid and A2.aname = 'Boeing')

The above query returns

(a) Finds the names of pilots who can operate with a range greater than 3000 Km.

(b) Finds the names of pilots but are not certified on any Boeing

(c) Finds the names of pilots who can operate with a range greater than 3000 Km, but are not certified on any Boeing

(d) Returns error

32.

Sid	sname	Rating	Age
18	Jones	3	30
41	Jonah	6	56
22	Ahab	7	44
63	Moby	null	15

Consider the table above, perform left outer join with itself and also right outer join with itself. Use join condition sid= sid for both left and right outer join and pick the correct answer from the following:

(a) Both left and right outer joins returns same number of rows.

(b) Left outer join returns more rows than right outer join.

(c) Right outer join returns more rows than left outer join.

(d) Cannot say.

33. Consider the schema.

Suppliers (sid, sname, address)

Parts(pid, pname, color)

Catalog (sid, pid, cost)

Select S.sname from Suppliers S

Where NOT EXISTS ((select * from Parts P where P.color='red')EXCEPT(select C.pid from catalog C, Parts P where C.sid= S.sid and C.pid= P.pid and P.color ='red'))

(a) Find the snames of suppliers who supply every red part.

(b) Find the snames of suppliers who supply every part.

(c) Find the pnames of parts supplied by every supplier.

(d) Find the pnames of parts supplied by supplier who also supplies red part.

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34. Consider the schema

Suppliers (sid, sname, address)

Parts(pid, pname, color)

Catalog (sid, pid, cost)

Select distinct C.sid from catalog C, parts P where C.pid= P.pid and P.color ='red"

Intersect

Select distinct C1.sid from catalog C1, parts P1 where C1.pid= P1.pid and P1.color ='green"

(a) It finds sids of suppliers who supply a red part

(b) It finds pids of suppliers who supply a red part and green part

(c) It finds sids of suppliers who supply a red part and green part

(d) It finds sids of suppliers who supply a green part

35. Select company-name from works

Group by company-name

Having count(distinct employee-name)>=all

(Select count (distinct employee-name) from works group by company-name)

The above query Returns

(a) Find the company that has the least employees

(b) Find the company that has the most employees

(c) Find the company that has the most or least employees

(d) Find the employee that has the most companies

Consider the schema below:

Suppliers (sid: integer, sname: string, address: string)

Parts (pid:integer, pname: string, color: string)

Catalog (sid: integer, pid: integer, cost: real)

36. Select P.pid, S.sname from Parts P, suppliers S, Catalog C

Where C.pid= P.pid

And C.sid = S.sid

And C.cost = (select max (C1.cost) from catalog C1 where C1.pid= P.pid)

What exactly the above query returns?

(a) Find the part of the supplier who charges the most for that part.

(b) For each part, find the sname of the supplier who charges the most for that part.

(c) Find the sname of the supplier who charges the least for that part.

(d) Find the sname of the supplier who charges the same charge for other parts.

37. To get zero rows from the above query, the operator '=' must be replaced with

(a) >=All (b) >=Any

(c) = Any (d) >All

38. Consider the schema:

Sailors (sid, sname, rating, age)

Reserves(Sid, bid, day)

Boats(bid, bname, color)

Find the names of sailors who have reserved both a red and a green boat.

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(a) SELECT S.sname FROM Sailors S, Reserves R, Boats B WHERE S.sid = R.sid AND R.bid = B.bid AND B.color = 'red' AND S.sid IN (SELECT S2.sid FROM Sailors S2, Boats B2, Reserves R2 WHERE S2.sid = R2.bid = B2.bid AND B2.color = 'green')

(b) SELECT S3.sname FROM Sailors S3 WHERE S3.sid IN ((SELECT R.sid FROM Boats B, Reserves R WHERE R.bid = B.bid AND B.color = 'red') INTERSECT (SELECT R2.sid FROM Boats B2, Reserves R2 WHERE R2.bid = B2.bid AND B2.color = 'green'));

(c) Both

(d) None

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Solutions

01. Ans: (c)

02. Ans: (b)

Sol: Union eliminate the duplicates.

03. Ans: (b)

04. Ans: (d)

Sol: Join is used to retrieve data from more than one table in a single SQL statement.

05. Ans: (c)

Sol: The query that has infinite results is called unsafe query.

06. Ans: (b)

Sol: If there are no columns in common natural join returns Cartesian product.

07. Ans: (b)

Sol: query (i) finds sailors with a lower rating than all the sailors with age less than 21.

query (ii) finds sailors with a higher rating than some sailors with age less than 21.

08. Ans: (d)

Sol: query (i) and (iii) finds numbers of reservations of each boat of color 'red' where as query (ii) returns an error.

09. Ans: (b)

Sol: query (ii) prints cname, st who has got a deposit and a loan.

query (iii) returns an error.

10. Ans: (d)

Sol: The tuples in the result of query is

R_1 A	R_1 B	R_2 A	R_2 B
2	1	2	1
3	2	2	1
3	2	3	2

Count (*) returns 3.

11. Ans: (d)

Sol: Inner query finds the Trainee of Ram and Ravi, the outer query finds name and trainer of everyone who has the same trainees as either Ram or Ravi.

12. Ans: (b)

13. Ans: (d)

Sol: The column job in having clause can't be used.

14. Ans: (a)

Sol: Intersection of R_1 and R_2 returns '0' tuples as minimum and n_1 tuples as maximum, as the condition $n_2 > n_1$.

15. Ans: (c)

Sol: Produces all pairs of empno having the same specialization.

16. Ans: (b)

Sol: If both r1 and r2 are non empty then only P.a1 = r1.a1 or P.a1 = r2.a1 condition becomes true.

17. Ans: (d)

Sol: The query finds all students whose name starts with 'A' only.

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18. Ans: (b)

Sol: Inner query finds total sales of all employees and outer query finds names and total sales of employee with highest total sales.

19. Ans: (d)

20. Ans: (a)

Sol: all(empty) returns true always.

21. Ans: (d)

22. Ans: (b)

Sol: Inner most query returns highest salary and its outer query returns highest salary from the remaining means, second highest salary and its outer query returns their eid's.

23. Ans: (c)

Sol: It is a correlated sub query. The outer query for each employee checks is there any dependent whose name is same as employee name

24. Ans: (d)

Sol: It is a natural join of R_1 and R_2 on $R_1.B = R_2.B$.

25. Ans: (d)

26. Ans: (c)

Sol: = all (empty) set returns true always.

27. Ans: (d)

28. Ans: (a)

Sol: As cruising range > distance means it is a non-stop flight.

29. Ans: (c)

Sol: Inner query finds eid's of certified pilot who can operate any Boeing.

30. Ans: (b)

Sol: Inner query finds number of guests trained by Julio, outer query finds trainer and number of guests trained by him if he trains more guests than Julio.

31. Ans: (c)

Sol: Outer query finds certified pilot who can operate with a range above 3000 and he is not a certified pilot of boeing.

32. Ans: (a)

Sol: As sid is a key and both left and right outer join returns same number of rows.

33. Ans: (a)

34. Ans: (c)

Sol: First query finds sid of suppliers who supply red parts and second query finds sid of suppliers who supply green parts.

35. Ans: (b)

Sol: Inner query finds number of employees of each company and the outer query finds company_name that has maximum employees.

36. Ans: (b)

Sol: It is a correlated sub query, finds for each part, sname of the supplies who changes the maximum.

37. Ans: (d)

38. Ans: (c)

Sol: Both options (a) and (b) returns sailor names who have reserved both red and green boats.

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Chapter 5 Relational Algebra & Calculus

01. What is the condition for the below expression to be true?

$\pi_x(\pi_y(R)) = \pi_y(\pi_x(R)) = \pi_y(\pi_x(R))$
$= \pi_x(\pi_y(\pi_z(R)))$

(a) $y \subseteq z, x \subseteq z, y = x$
(b) $y \subseteq z, x \subseteq z, x \subset y$
(c) $y \subseteq x, x \supseteq z, z \supseteq y$
(d) $x \subseteq y, y \subseteq z$

02. Consider a join of a relation R with a relation S. If R has m tuples and S has n tuples, then the maximum and minimum sizes of the join respectively are

(a) m + n and 0
(b) m + n and |m – n
(c) mn and min of {m, n}
(d) mn and 0

03. Which of the following is a false statement?

(a) Relational algebra is a procedural language.
(b) Tuple relational calculus and domain relational calculus are non procedural languages.
(c) QBE is based on domain relational calculus.
(d) QUEL is based on tuple relational calculus
(e) None

04. Every operator in relation algebra accepts one or more relation instances as arguments and the result is always

(a) Relation instance
(b) Value
(c) Sometimes relation instance, sometimes none
(d) Operator

05. Consider the following three relations.

R

Jno	Sno
J2	S1
J1	S1
J1	S2

Q

Pno	Jno
P1	J2
P2	J1
P1	J1

S

Sno	Pno
S1	P1
S1	P2
S2	P1

Query: $((R \bowtie Q \bowtie S)$

Find out the no. of rows results comes as output for the above Query.

(a) 4
(b) 5
(c) 6
(d) None of the above values

06. **Customer**

cname	st	City

Account

acno	cname	bal	bname

Loan

lno	cname	amt	bname

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Query (i): Select cname From Customer Where cname in (Select cname From Account where cname = any(select cname From loan));

Query (ii): $(\Pi_{cname}((Customer \bowtie Account) \bowtie loan))$

Query (iii): $(\Pi_{cname}(Customer \bowtie (Account \bowtie loan)))$

Query (iv): Select cname From Customer C Where exists ((Select cname From loan) Intersect (Select cname From Account where cname = C.cname));

Which of the following is false statement?

(a) Query(i) & Query(iv) gives the same result.

(b) Query(ii) & Query(iii) gives the same result.

(c) Query(i) and Query(iii) gives the different result.

(d) Query(iii) & Query(iv) gives the same result.

07. **Deposit**

acno	cname	Bal	bname

Borrow

lno	cname	Amt	bname

Query1: $\{t/\exists S \in deposit\ (t[cname] = S[cname]) \wedge \exists u \in borrow\ (s[cname]=u[cname])\}$

Query2: $\{t/\exists S \in deposit \wedge \exists u \in borrow\ (t[cname] = s[cname] \wedge s[cname]=u[cname])\}$

Query3: $(\Pi_{cname}(\rho_d(deposit) \bowtie_{d.cname=b.cname} \rho_b(barrow)))\}$

Query4: Select cname From Deposit where cname in (Select cname from barrow)

Which of the following is a true statement?

(a) Query1 and Query2 results are different.

(b) Query2 and Query4 results are different.

(c) Query2 and Query3 results are same but Query1 results are different.

(d) Query1, Query2, Query3, Query4 gives the same result.

08. Find equivalent Relational Algebra (RA) expression for the following SQL query.

Select C.sid from catalog C, parts P where (P.color = red or P.color = green) and P.pid=C.pid

(a) Π sid ($\sigma_{color=red\ or\ color=green}$ (parts) $\bowtie$ catalog)

(b) Π sid ($\sigma_{color= red\ or\ color = red}$ (parts) $\bowtie$ catalog)

(c) Π pid($\sigma_{color= red\ or\ colo = green}$ (parts) $\bowtie$ catalog)

(d) Π pid ($\sigma_{color=red\ or\ color= green}$ (parts) $\bowtie$ catalog)

09. If R = {(1,2)} and S = {(1,3)},

then result of $\Pi_A(R) - \Pi_B(S)$,

where A and B are the columns in R and S

(a) Non empty (b) Empty

(c) Syntax error (d) None of these

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10. Consider the RA expression Π_a (R1), table R1 has attribute 'a' and rows N1>0.
Find the minimum and maximum rows returned by the RA expression
(a) 0, 100 (b) 0, N1
(c) 1, N1 (d) N1, 1

11. Consider two relations R_1, R_2 with N_1 and N_2 tuples where $N_2 > N_1 > 0$.
What are the minimum and maximum rows for the RA expression R_2/R_1?
(a) 0, N_1/N_2 (b) N_1, N_1/N_2
(c) 0, N_2/N_1 (d) N_2/N_1, 0

12. The following two questions *involve* the three relations below:
1. R(a, b) = {(0, 1), (4, 5), (8, 9)}.
2. S(b, c) ={(1,2), (5, 2), (5, 6),(5, 10),(13, 10)}.
3. T(c, d) = {(2, 3), (6, 7), (10, 11), (10, 3)}.
The number of tuples in R ⋈ S ⋈ T, where ⋈ is the natural join is:
(a) 5 (b) 8
(c) 10 (d) 13

13. Consider the following relation schemas:
PROJECT(project#, project name, chief_architect) Employee Emp#, Emp_name) Assigned_to(project#, Emp#)
EMPLOYEE ⋈ $\pi_{Emp\#}$ (ASSIGNED_TO)
(($\pi_{project\#}$ (PROJECT) − ⋈ ($\pi_{project\#}$ $\sigma_{Emp\# = 107}$ (ASSIGNED_TO)))
The above query indicates:
(a) Get complete details of the employees who are assigned to the projects not assigned to the employee 107.
(b) Get complete details of the employee 107 and project handled by employee 107.
(c) Get complete details of the employees who are assigned to the project assigned to the employee 107.
(d) None of the above

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Solutions

01. Ans: (a)

Sol: x and y must be equal and both are subset or equal to z.

02. Ans: (d)

Sol: If there are no attributes m common the join relations only cartesian product.

03. Ans: (e)

04. Ans: (a)

05. Ans: (b)

Sol:

R ⋈ Q

Jno	Sno	Pno
J_2	S_1	P_1
J_2	S_1	P_2
J_1	S_1	P_1
J_1	S_1	P_2
J_1	S_1	P_1

(R ⋈ S) ⋈ S

Jno	Sno	Pno
J_2	S_1	P_1
J_1	S_1	P_1
J_1	S_1	P_2
J_1	S_2	P_1

06. Ans: (d)

Sol: All the queries, find name of the customers who have both account and loan.

Relational Algebra eliminate the duplicates

07. Ans: (d)

Sol: All the queries, find name of the customers who have an account and loan.

08. Ans: (a)

09. Ans: (b)

Sol: $\Pi_A(R)$ returns {1}

$\Pi_B(S)$ returns {1}

Then $\Pi_A(R) - \Pi_B(S)$ returns empty set.

10. Ans: (c)

Sol: If column 'a' has all same values it return 1 row otherwise i.e., if no duplicates returns N1 rows.

11. Ans: (c)

Sol: R_2/R_1 gives minimum of zero rows, as there is no row in R_2 for each row of R_1.

R_2/R_1 gives maximum of N_2/N_1 rows, as there a row in R_2 for each row of R_1.

12. Ans: (a)

Sol:

R ⋈ S

a	b	c
0	1	2
4	5	2
4	5	6
4	5	10

R ⋈ S ⋈ T

a	b	c	d
0	1	2	3
4	5	2	3
4	5	6	7
4	5	10	11
4	5	10	3

13. Ans: (a)

Sol: Inner query finds projectid's of projects that are assigned to employee 107. Outer query returns details of such employee

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Chapter 6 Transactions & Concurrency Control

01. Logical unit of work is

(a) transaction (b) block

(c) record (d) bucket

02. In the following schedule transaction T_1 and T_2 are running concurrently. The execution of operation is given. Find which of the following problems it is suffering from.

T_1	T_2
Read A	
A = A – 100	
Read B	
	Read A
	Read B
	A=A+100
	B=B+100
	Write A
	Write B
B=B+100	
Write A	
Write B	

(a) phantom phenomenon

(b) unrepeatable read

(c) uncommitted read

(d) lost update problem

03. A schedule is having three transactions T_1, T_2, T_3 running concurrently with the following operations.

It is equivalent to the following serial scheduler.

T_1	T_2	T_3
Read y		
y = y + 100	Read z	
Write y	z = z + 100	Read x
	Write z	x = x – 100
		Write x
Read x		
x = x +100	Read y	
Write x	y = y – 100	Read y z
	Write y	z = z – 100
Read z		Write z
z = z + 100	Read x	
Write z	x = x + 300	Read y
	Write x	y = y + 500
		Write y

(a) $T_1 \rightarrow T_3 \rightarrow T_2$ (b) $T_3 \rightarrow T_2 \rightarrow T_1$

(c) $T_1 \rightarrow T_2 \rightarrow T_3$ (d) None

04. T_1 : Read A ; T_2 : Read B; T_2 : Write B; T_3 : Read A; T_3 : Write A; T_1 : Read B; T_3 : Read B; T_2 : Read A; T_2 : write A

The above schedule is

(a) view serializable

(b) conflict serializable

(c) both

(d) Can't serializable

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05. Is the below schedule can be serializable

T_1	T_2	T_3
Read B		
		Read C
Read A		
	Write A	
Write A		
	Write B	
		Write A
Write B		
		Write B
		Write C

(a) conflict serializable
(b) view serializable
(c) both
(d) can't be serializable

06. A schedule (S : T_2 : Read A; T_3: Read B; T_2: Write A; T_1 : Read A; T_3 : Write B; T_2: Read B; T_1 : Write A; T_2 : Write B; T_2: Read C; T_2 : Write C; T_1 : Read C; T_1: Write C; T_3: Write B)
Is the above schedule is serializable if yes it is equivalent to which serial schedule
(a) T_1: T_2 : T_3
(b) It is not serializable
(c) T_2 : T_1 : T_3
(d) T_3: T_2 : T_1

07. A schedule S : T_1 : Read A; T_2 : Read B; T_3 : Read C; T_3 : Write C; T_2 : Write B; T_1 : Write A is equivalent to which of the following serial schedule.
(a) T_1 : T_2 : T_3
(b) T_2 : T_1: T_3
(c) T_3 : T_2 : T_1
(d) It is equivalent to all possible serial schedule with T_1, T_2, T_3

08. T_1, T_2 and T_3 are independent transaction and are equal to all possible serial schedules.
The above schedule is _____ serializable
(a) view (b) conflict
(c) both (d) none

09. In schedule S there are 4 transactions each transaction is reading two data items and updating (on writing) the same and no two transactions are sharing the same data items. Then the schedule is equivalent to _____ number of serial schedule.
(a) 4 (b) 8
(c) 16 (d) 24

10. A schedule S is having 3 transactions and each transaction is having two different data items and a blind 'Write A' statement is in all the three transactions.
With the above information can you say whether the schedule is serializable or not.
(a) can't say
(b) serializable but it is not possible to determine how many equivalent serial schedules are there
(c) serializable and it is equivalent to only two serial schedule
(d) detailed schedule is needed.

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11. An application program is using the isolation level 'UnCommitted Read'. Which of the following problems are possible.

(I) Dirty Read
(II) Unrepeatable Read
(III) Lost update

(a) I, II & III (b) II & III
(c) I & II only (d) II only

12. Which of the following statement is false?
(a) Conservative or static 2 PL protocol is dead lock free and guarantees recoverable schedule.
(b) Strict 2 PL protocol is not dead lock free and guarantees serializable schedules.
(c) Basic timestamp ordering suffers from cascading roll back (i.e., not recoverable schedule) and dead lock free.
(d) strict time stamp ordering is recoverable and conflict serializable
(e) None

13. In multiple Granularity locking protocol at a particular node transaction T_1 is holding SIX LOCK. When transaction T_2 is also requesting a lock, at that node which other lock is allowed.
(a) I S (b) I X
(c) S (d) SIX (e) X

14. A schedule S : T_1 : write A ; T_2 : Read A ; T_2 : write B ; T_2 : commit ; T_1 : Roll back. For the above schedule which of the following problem it is facing?
(a) Cascading Roll back
(b) UnRepeatable Read
(c) Non Recoverable Schedule
(d) None

15. A schedule S contains three transactions T_1, T_2, T_3 and the operations sequence is given below:
T_1: Read A; T_2: Write A; T_3: Read A; T_1: Write A; T_3: Write A and all the above transactions are committed. Is the above schedule is serializable or not? If yes it is equivalent to which serial schedule. Find the proper combination of the given alternatives from I to VII.

I. View serializable
II. Conflict serializable
III. Both
IV. Not serializable
V. T_2; T_1; T_3
VI. T_1; T_2; T_3
VII. T_2; T_3; T_1

(a) Only IV (b) II, V
(c) I, VI (d) I, V

16. A schedule S with T_1 and T_2 transactions is having following operations sequence.
T_1: Read A; T_2: Write A; T_2: Commit; T_1: Write A; T_1: Commit.
The above schedule is serializable under which concurrency control protocol.

(a) Strict 2 PL
(b) Conservativ
(c) Time stamp
(d) Time stam

17. A schedule S:
T_2: Write(y);
T_1: commit;
The above sc
(a) view seri
(b) conflict
(c) Recover
(d) not seri

18. Consider
T_2, T_3 wit
serializabi
serializab
schedule.
S: T_1: Re
T_3: Read
T_3: Writ
T_2: Writ
(a) T_3,
(c) T_2,

19. Which
under
S1: r_1(
S2: r_1
S3: r_3
S4: r
(a) S
(c) S

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(a) Strict 2 PL
(b) Conservative 2 PL
(c) Time stamp without Thomas write rule
(d) Time stamp with Thomas write rule

17. A schedule S: T_1: Read(x); T_2: Write(x); T_2: Write(y); T_3: Write(y); T_1:Write(y); T_1: commit; T_2: commit; T_3: commit
The above schedule is _____
(a) view serializable
(b) conflict serializable
(c) Recoverable
(d) not serializable

18. Consider the schedule with transactions T_1, T_2, T_3 with the following schedule. Draw the serializability or not. If the schedule is serializable, write down the equivalent serial schedule.
S: T_1: Read(x); T_2: Read(z); T_1: Read(z); T_3: Read(x); T_3: Read(y); T_1: Write(x); T_3: Write(y); T_2: Read(y); T_2: Write(z); T_2: Write (y)
(a) T_3, T_2, T_1
(b) T_1, T_2, T_3
(c) T_2, T_1, T_3
(d) T_3, T_2, T_1

19. Which of the following schedule is allowed under basic timestamp protocol
S1: $r_1(x)$, r_3 (x), $w_1(x)$, $r_2(x)$, $w_3(x)$
S2: $r_1(x)$, r_3 (x), $w_3(x)$, $w_1(x)$, $r_2(x)$
S3: $r_3(x)$, r_2 (x), $w_3(x)$, $r_1(x)$, $w_1(x)$
S4: $r_1(x)$, r_3 (x), $r_2(x)$, $w_1(y)$, $w_3(y)$
(a) S1
(b) S2
(c) S3
(d) S4

20. Consider three data items D1, D2, D3 and the following execution schedule of transactions T1, T2 and T3. In the diagram, R(D) and W(D).Denote the actions reading and writing the data item D respectively.

	T1	T2	T3
Time		R(D3);	
		R(D2);	
		W(D2);	
	R(D1);		R(D2);
	W(D1);		R(D3)
		R(D1)	W(D2)
			W(D3)
	R(D2);	W(D1);	
	W(D2);		

(a) The schedule is serializable as T2;T3;T1
(b) The schedule is serializable as T2;T1;T3
(c) The schedule is serializable as T3;T2;T1
(d) The schedule is not serializable

21.

Transaction	Time – stamp
T_{22}	5
T_{23}	10
T_{24}	15

According to wait –die scheme:
(a) If T_{22} requests a data item held by T_{24}, then T_{23} will be rolled back
(b) If T_{24} requests a data item held by T_{23}, then T_{24} will not be rolled back
(c) If T_{22} requests a data item held by T_{23}, then T_{22} will wait
(d) If T_{22}, T_{23} requests a data item held by T_{24}, then T_{22} will be rolled back

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22. In the following schedule transaction T_1 and T_2 are running concurrently.
The execution of operation is given. Find which of the following problems it is suffering from.

T_1	T_2
Read A A = A – 100 Read B	
	Read A Read B A = A+100
	B = B+100 Write A Write B
B = B+100 Write A Write B	

(a) phantom phenomenon
(b) repeatable read
(c) uncommitted read
(d) lost update problem

23. Consider a tablespace is having two tables T_1 and T_2, each table is collection of pages, each page is collection of rows. Which of the following locking sequence is invalid in multiple Granularity protocol. The locking sequence is given in the order of table space, table, page and row.

(a) 1X, 1X, 1S, S
(b) 1X, S1X, 1X, X
(c) S1X, S1X, 1X, X
(d) S1X, 1X, 1S, S

24. Which of the following is a false statement?
(a) A schedule which is allowed under strict 2PL is always allowed under Basic 2PL.
(b) A Schedule which is allowed under Basic Timestamp protocol is always allowed under Thomas write rule.
(c) A Schedule which is allowed under Basic 2PL is always allowed under multiversion2PL.
(d) A Schedule which is allowed under multiversion 2PL is always allowed under multiversion Timestamp protocol.

25. Which of the following is a false statement?
(a) Conflict serializable Schedules are allowed under Thomas write rule.
(b) Wound-wait protocol prevents starvation.
(c) Timer out can be used for deadlock recovery.
(d) Thomas Write rule allows all view serializable schedules.

26. Consider the below nonserial schedule S :

T_1	T_2	T_3
R(A)		
	R(A)	
W(A)		R(B)
	W(A)	
		W(B)

Assertion [A]: The given non serial Schedule is a view serializable.
Reason [R]: The given schedule S is conflict serializable.

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(a) Both (a) and (r) are true and (r) is the correct reason for (a).
(b) Both (a) and (r) are true but (r) is not the correct reason for (a).
(c) Both (a) and (r) are false.
(d) (a) is true but (r) is false.

27. Match the following:

List-I

P. Atomocity
Q. Isolation
R. Durability
S. Consistency Preservation

List-II

1. Recovery Manager
2. User
3. Concurrency Control Sub system
4. Transaction Manager

(a) P-4, Q-3, R-1, S-2
(b) P-2, Q-4, R-1, S-3
(c) P-1, Q-3, R-4, S-2
(d) P-1, Q-3, R-4, S-2

28. In a non serial schedule one transaction is waiting for other transaction as below.

→ Transaction T27 is waiting for data items locked by transaction T28 and T31
→ Transaction T28 is waiting for data items locked by transaction T29 and T30
→ Transaction T33 is waiting for data items locked by transaction T31
→ Transaction T29 is waiting for data items locked by transaction T31 and T32
→ Transaction T32 is waiting for data items locked by transaction T33
→ Transaction T30 is waiting for data items locked by transaction T31

The above Schedule is having a deadlock.

(a) True (b) False

29. Consider the non serial schedule S : $R_1(A)$, $W_1(B)$, $R_2(B)$, $R_3(C)$, $W_1(A)$, $R_4(A)$, $R_2(C)$, $W_4(A)$, $W_3(B)$, $R_4(B)$, $W_4(C)$.

The given non serial schedule is conflict equivalent to the following serial schedule.

(a) $T_1 \rightarrow T_3 \rightarrow T_2 \rightarrow T_4$
(b) $T_2 \rightarrow T_1 \rightarrow T_3 \rightarrow T_4$
(c) $T_1 \rightarrow T_2 \rightarrow T_3 \rightarrow T_4$
(d) Not Serializable

30. Consider a non serial schedule S has executed in the following order.

S: $W_3(C)$, $R_1(A)$, $W_1(A)$, $R_1(B)$, $W_2(B)$, $W_2(C)$, $R_3(A)$, Commit3, $W_1(C)$, commit1, Rollback2.

The above given schedule is .....

(a) Recoverable schedule
(b) Cascading rollback schedule
(c) Cascadeless rollback schedule
(d) Non recoverable schedule

31. Consider a non serial schedule S has 4 transactions and the execution of operation is given below:

S: $R_1(A)$, $R_4(B)$, $W_3(A)$, $W_2(B)$, $W_4(C)$, $Commit_4$, $W_3(C)$, $W_1(A)$, Commit1, $R_2(D)$, $W_3(D)$, $Rollback_3$;

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The above given Schedule is _____.

(a) Recoverable schedule

(b) Cascading rollback Schedule

(c) Cascadeless rollback schedule

(d) Both (a) and (c)

32. **Data:** Consider a non serial schedule S is having 3 transactions and operation of those transactions are executed as below:

S: R2 (A), W2(B), R1(A), R3(A), W2(C), commit2, R1(B), R3(C), W1(B), commit1, W2 (C) commit3,

Assertion [A]: The given schedule S is strict schedule.

Reason [R]: The schedule S is allowed under Rigorous 2PL.

Choose:

(a) Both (a) and (r) are true and (r) is the correct reason for (a).

(b) Both (a) and (r) are true but (r) is not the correct reason for (a).

(c) Both (a) and (r) are false.

(d) (a) is true but (r) is false.

Common data for 33 & 34

Consider the following schedule S has 4 Transactions.

S:$R_1(A)$, $R_2(B)$, $Commit_2$, $R_3(C)$, $W_1(A)$, $R_3(A)$, $W_1(B)$, $Rollback_1$, $W_3(A)$, $R_4(B)$.

33. What is category of this schedule based on recoverability?

(a) Recoverability schedule

(b) Cascading rollback schedule

(c) Non recoverable schedule

(d) Cascadeless rollback schedule

34. The given schedule is allowed under which of the following protocol.

(a) Basic Timestamp protocol

(b) Thomas Write Rule

(c) Basic 2PL

(d) None of protocols given.

35.

T_1	T_2
$w_1(x)$	
	$r_2(x)$
$w_1(x)$	
	c_2
c_1	

(a) recoverable, cascade less

(b) not recoverable, cascade less

(c) recoverable, not cascade less

(d) not recoverable, not cascade less

36. If isolation level in transactions is set as "read committed", then

(1) Dirty reads are not allowed

(2) Unrepeatable reads are allowed

(3) Phantom rows are not allowed

(4) Phantom rows are allowed

(a) 1, 2, 3 are correct

(b) 1, 2, 4 are correct

(c) 2, 3, 4 are correct

(d) None of the above

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37. $T_1 : R(x), T_2 : R(x), T_1 : W(x), T_2 : W(x)$, find the characteristic of the schedule
(a) Conflict serialiazable, recoverable, cascadeless
(b) Conflict serialiazable, not recoverable, cascadeless
(c) Conflict serialiazable, recoverable, not cascadeless
(d) Not Conflict serialiazable, recoverable, cascadeless

38. In multiple granularity protocol at a particular data item, transaction T_1 is holding shared intension exclusive lock. At the same data item, transaction T_2 is allowed to request which of the following locks?
(a) intension exclusive
(b) intension shared lock
(c) shared lock
(d) excessive lock

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Solutions

01. Ans: (a)

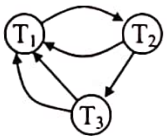
Sol: Transaction is a collection of operations that performs one logical unit of work.

02. Ans: (d)

Sol: Updates of T_2 are overwritten by T_1, hence it suffers with lost update problem

03. Ans: (d)

Sol: The precedence graph of above schedule is



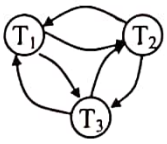
The schedule is not c.s.

04. Ans: (d)

Sol:

T_1	T_2	T_3
R(A)		
	R(B)	
	W(B)	
		R(A)
		W(A)
R(B)		
	R(A)	R(B)
	W(A)	

Pecedence graph is



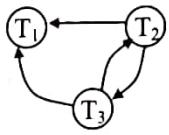
The schedule is not c.s and not v.s.

05. Ans: (b)

Sol: The above schedule is view Serializable to serial schedule $T_1 \rightarrow T_2 \rightarrow T_3$.

06. Ans: (b)

Sol: Precedence graph is



07. Ans: (d)

Sol: T_1, T_2 and T_3 are independent transactions and are equal to all possible serial schedules.

08. Ans: (c)

Sol: Independent transactions always satisfies the serializibility.

09. Ans: (d)

Sol: Number of serial schedules possible with 4 Transactional is 4! That is 24.

10. Ans: (c)

Sol: A schedule that is not conflict serializable then there must be atleast one blind write to become schedule view serializable.

11. Ans: (c)

12. Ans: (a)

Sol: Strict 2PL is not free from deadlocks.

13. Ans: (a)

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14. Ans: (a)

Sol: As T_2 Performs dirty-Read operation then cascading rollbacks are possible

15. Ans: (a)

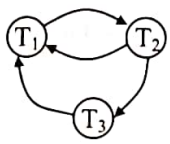
Sol: Not Serializable schedule.

16. Ans: (c)

Sol: Schedule is executing in the order of its timestamp $T_1 \rightarrow T_2$.

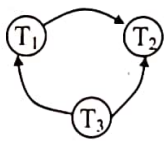
17. Ans: (d)

Sol: precedence graph



18. Ans: (a)

Sol: Precedence graph



19. Ans: (d)

20. Ans: (d)

Sol: Precedence graph contains cycle from $T_1 \rightarrow T_2$ and $T_2 \rightarrow T_1$.

21. Ans: (c)

Sol: In wait-die scheme, an older transaction requesting an item held by a younger transaction will wait, whereas a younger Transaction requesting an item held by an older transaction will die.

22. Ans: (d)

Sol: The updates of T_2 are overwritten by the updates of T_1.

23. Ans: (d)

24. Ans: (d)

25. Ans: (d)

Sol: Thomas write rule not allows all view serializable schedules

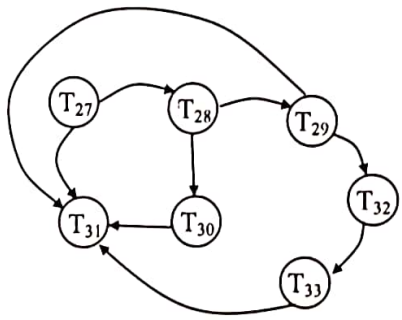
26. Ans: (c)

Sol: The schedule is not conflict serializable, as its precedence graph contains cycle and there is no blind write operation, it is not view serializable.

27. Ans: (a)

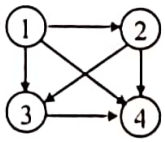
28. Ans: (b)

Sol: Precedence graph as per locks.



29. Ans: (c)

Sol: Precedence graph



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30. Ans: (d)

Sol: If T_1 fails after T_3 commits, requires to Rollback both T_1 & T_3.

31. Ans: (d)

Sol: Every strict schedule is both recoverable and cascade less.

32. Ans: (d)

Sol: A schedule is said to be strict, if a value written by a Transactions T is not Read or written by another transaction until T commits or aborts.

33. Ans: (a)

Sol: As there is no dirty read operation in the given schedules and it is both recoverable and cascadless.

34. Ans: (c)

35. Ans: (d)

Sol: T_2 committed before T_1 commits.

36. Ans: (b)

Sol: Read committed data will not cause dirty Read problem, but causes unrepeatable reads and phantom tuple problems.

37. Ans: (d)

Sol: Precedence graph contains cycles from $T_1 \rightarrow T_2$ and $T_2 \rightarrow T_1$, as there is no commits is Recoverable & cascades.

38. Ans: (b)

Sol: If a node is locked in SIX mode by T_1, then other transaction T_2 can lock the same data item in IS mode.

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Chapter 7 Indexing

01. When would you want to use a B-tree instead of B^+ tree?

I. When sequential access to key values is never required.

II. When sequential access to key values is required.

III. When both sequential and direct access is required.

IV. When direct access is required without sequential access.

(a) III only (b) II only

(c) I only (d) IV only

02. What is the maximum height of B-tree with order-m and having N-keys?

(a) $[\log_{\lceil m/2 \rceil} N]$ (b) $[\log_{(m/2)} N+1]$

(c) $[\log_{(m/2)-1} N]$ (d) none

03. Insertion of data into B-tree may cause

(a) height increase

(b) no change in height & no change in no. of nodes

(c) splitting the node

(d) all the above

04. In B^+ trees deletion causes the height will _____.

I. no change II. decreased by 1

III. decreased by 2

(a) I only (b) II only

(c) I & II (d) I, II & III

05. An index record appears for every search key value in a file and a pointer to the record. This is example for

(a) sparse index

(b) dense index

(c) primary key index

(d) secondary key index

06. Assume that you have built a dense primary B+ tree index on a heap file containing 20,000 records. The key field for this B+ tree index is a 40 byte string and it is a candidate key. Pointers (i.e. record ids and page ids) are (at most) 10 byte values. The size of one disk page is 1,000 bytes . The index was built in a bottom-up fashion using the bulk-loading algorithm, and the nodes were filled up as much as possible. Then there are _____ number levels in the tree.

(a) 4 levels

(b) 5 levels

(c) 3 levels

(d) 6 levels

07. Consider a disk with block size B = 512 bytes. A block pointer is P = 6 bytes long and a record P_R = 7 bytes long. A file has 30000 employee records of fixed length, each record size is fixed of 50 bytes. Find out the number of file blocks 'b' required, assuming an unspanned organization.

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(a) 2800 blocks
(b) 2800 <b< 2900 blocks
(c) 3000 blocks
(d) None

08. Consider B tree where size of the node is 512 bytes.
Search key field = 9 bytes, block pointer = 6 bytes, data pointer = 7 bytes.
Find the order of the tree and number of data entries in level 2 if fill factor of the page is 0.69.
(a) 16, 3840 (b) 16, 61440
(c) 16, 15 (d) 16, 16

09. Pick up the *correct* statements of the following:
P: All conflict serializable schedules are also view serializable schedules.
Q: B+ tree will have more redundancy than B tree.
R: Weak entity is always having total participation.
S: R1(x), W2(y) are conflict operations.
T: Read and write locks are released only after commit in rigorous two phase locking protocol
U: ALL and ANY conditions will return TRUE if inner query returns an empty set.
(a) P, Q, R, T
(b) P, R, S, T, U
(c) P, R, T
(d) P, Q, T

10. Given that the block size is 512 bytes, search field is 9 bytes, record pointer is 7 bytes and a block pointer is 6 bytes long, what are the orders of internal and leaf nodes of B^+-tree respectively?
(a) 31, 34 (b) 34, 31
(c) 32, 33 (d) 34, 32

11. Consider a disk with block size = 1024 bytes, A block pointer 6 bytes and record pointer 8 bytes. The file has 10000 employee records. Every record is fixed length of 100 bytes. Its key is SSN which is of 2 bytes. The file is not ordered by the key field (SSN) and want to construct a secondary index on SSN. Find out the no. of blocks required in first level index.
(a) 100 blocks (b) 99 blocks
(c) 117 blocks (d) 116 blocks

12. For the above file, if we make it into multilevel index, find out the no. of total blocks required.
(a) 102 blocks (b) 100 blocks
(c) 119 blocks (d) 118 blocks

13. Consider the file consists of 30,000 fixed length records of size 100 bytes. Each disk block size is 1024 bytes and block pointer size is 6 bytes. Suppose we construct a secondary index on key field of length 9 bytes long then find out the no. of block needed for index file?
(a) 441 (b) 434
(c) 435 (d) 442

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14. Which of the following is a false statement?
(a) Insertion of a search key in B^+-Tree may cause height to be increased one level.
(b) Deletion of a search key in B-Tree may cause height to be decreased by one level.
(c) Insertion of a search key into a B-Tree may or may not increase the height.
(d) Deletion of a search key will not decrease the height of a B^+-Tree as B^+ Tree allows duplicate values.

15. Suppose we have an ordered file with 30,000 records stored on a disk with block size 1024 bytes stored based on key field of length 9 bytes and Block pointer of 6 bytes. File records are of fixed length and are unsnapped, with record length 100 bytes. If we construct an index on the above key field, find out the total number of blocks required in index file?
(a) 44 blocks (b) 45 blocks
(c) 441 blocks (d) 442 blocks

16. Consider a block size 512 bytes, search key field 9 bytes long and block pointer size 6 bytes long. If a level 3 B^+ tree is constructed considering root as level 0, find out the maximum number of entries in the B^+ tree ?
(a) $(34)^2$ * 33 entries
(b) $(34)^3$ * 33 entries
(c) $(35)^2$ * entries
(d) $(35)^3$ * 34 entries

17. Consider a disk with block size 512 bytes. A block pointer 6 bytes long, record pointer 7 bytes long. A file has 30,000 employee records of fixed length 100 bytes and with a key field 9 bytes long.
Suppose that the file is ordered by the key field SSN and we want to construct a multilevel index on SSN field. Find out the number of block accesses needed to search for and retrieve the record from file for given SSN value using the index?
(a) 3 blocks (b) 4 blocks
(c) 5 blocks (d) more than 5 blocks

18. How many clustered indexes a table can have
(a) Any
(b) Can't say
(c) Depends on columns in the table
(d) None of the above

Statement for Linked answer 19 and 20 is given below.

Consider the following description:
To construct the B+ tree use the following values. Consider the database block size as 512 bytes, block pointer as 6 bytes, record pointer as 7 bytes and search key value as 9 bytes.

19. What is the order of the B+ tree internal node.
(a) 23 (b) 32 (c) 34 (d) 44

20. What will be the number of data entries possible in level 2 of the B+ tree, if fill factor of the node is 0.8
(a) 17, 954 (b) 16, 954
(c) 18, 954 (d) 17, 496

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21. What is the minimum space utilization for a B+ tree index with the exception of the root?
(a) 0 %
(b) 100%
(c) 50 %
(d) None of these

22. What is the difference between a primary index and a secondary index?
(a) There can be only one secondary index while there can be many primary indices
(b) There can be many secondary indices while there can be many primary indices
(c) Primary is dense index, but secondary is sparse index
(d) There can be only one primary index while there can be many secondary Indices

23. Select * from student where marks > 50 and marks < 80, pick the correct index to have optimized results.
(a) Clustered B^+ tree index is best suited
(b) Non Clustered B^+ tree index is best suited
(c) Both are having equal impact
(d) Both are not useful

24. Database consists 30,000 records and each record length is 100 bytes. Consider block size =1024 bytes. Find the number of searches required without primary index if search key field value = 9 bytes and block pointer = 6 bytes.
(a) $\log_2 30000$
(b) $\log_2 3000$
(c) $\log_2 4$
(d) $\log_2 3045$

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Solutions

01. Ans: (d)

Sol: B – tree uses direct access and B^+ - tree uses sequential access.

02. Ans: (a)

03. Ans: (d)

04. Ans: (c)

Sol: Insertion and deletion will increase or decrease its weight only by one but not two.

05. Ans: (b)

Sol: A dense index has an index entry for every search key value.

06. Ans: (a)

Sol: Size of index = 40 + 10 = 50 bytes

Blocking factor $= \frac{1000}{50} = 20 \text{records/Block}$

No. of 1st level index records = 20,000

$\Rightarrow$ No. of 1st level blocks

$$= \frac{20000}{20} = 1000 \text{ blocks}$$

No. of 2nd level blocks $= \frac{1000}{20} = 50 \text{ blocks}$

No. of 3rd level blocks $= \frac{50}{20} = 3 \text{ blocks}$

No. of 4th level blocks $= \frac{3}{20} = 1 \text{ block}$

$\therefore$ There are 4 levels in the tree.

07. Ans: (c)

Sol: Blocking Factor $= \frac{512}{50} = 10$

No. of Blocks $= \frac{30000}{10} = 3000$

08. Ans: (a)

Sol: Order = n ×6 +(n–1) 16 <= 512, $n \le 24$

If 69% full order = 16,

No of index records = 3840

09. Ans: (a)

Sol: R1(x), W2(y) are not conflict operations, as is on different d. All an empty set returns true, but ANY returns false.

10. Ans: (b)

Sol: Internal node order

$n \times 6 + (n-1)9 \le 512$

$15n \le 521$

$n \le 34$

leaf node order $= n \times (9 + 7) + 6 \le 512$

$16n \le 506$

$n \le 31$

11. Ans: (b)

Sol: Index record size = 2 + 8 = 10 bytes

Blocking factor $= \frac{1024}{10}$

$= 102$

No. of 1st level blocks $= \frac{10000}{102}$

$= 99 \text{ blocks}$

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Chapter 1 Concept of Layering

01. What addressing system has topological significance?

(a) Logical (b) Physical

(c) Port (d) None of these

02. Match the following:

List – I	List – II
(1) Repeater	(a) Transport layer
(2) Hub	(b) Data link layer
(3) Bridge	(c) Physical layer
(4) Switch	(d) Network layer
(5) Router	(e) Application layer
(6) Transport gateway	
(7) Application gateway	

Codes:

(a) 1–b, 2–c, 3–b, 4–b, 5–b, 6–a, 7–b

(b) 1–c, 2–c, 3–b, 4–b, 5–d, 6–a, 7–e

(c) 1–c, 2–b, 3–b, 4–b, 5–d, 6–d, 7–e

(d) 1–c, 2–c, 3–b, 4–c, 5–d, 6–a, 7–a

03. _____ address on headers changes as a packet moves from one network to another.

(a) Logical

(b) Physical

(c) Logical or Physical

(d) Neither Logical nor Physical

04. The following devices are used between/across different networks.

(P) Switch (Q) Bridge

(R) Router (S) Gateway

Then devices that their operation based on logical addresses are:

(a) both [P]&[R] (b) both [Q]&[R]

(c) both [P]&[S] (d) both [R]&[S]

05. In Wireless communication which of the following is preferred

(a) Error correction (b) Error Detection

(c) Both (a) & (b) (d) None of these

06. Basic Data Transfer, Reliability, Flow Control, Multiplexing, Connections, Precedence and Security are functions of which layer.

(a) Data link layer

(b) Application layer

(c) Network layer

(d) Transport layer

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Solutions

01. **Ans: (a)**

Sol: Logical address is also called as IP address. Physical address is permanent. Port number gives us the service point.

02. **Ans: (b)**

Sol: Repeater – physical layer } Connects multiple work stations
Hub – physical layer

Bridge – } Data link layer– connects multiple similar LAN's or subnets
Switch –

Router – Network layer – connects different similar networks

Transport Gateway – Transport layerApplication Gateway – Application layer

03. **Ans: (b)**

Sol: Physical address (MAC address) changes from one network to another.

04. **Ans: (d)**

Sol: Router forwards the packet based IP address. Gateway connects two or more different dissimilar networks.

05. **Ans: (a)**

06. **Ans: (d)**

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Chapter 2 LAN Technologies

01. If 'B' is the network bandwidth, 'L' is the cable length and 'C' is the speed of the signal propagation, 'e' is the number of contention slots per frame and 'F' is the frame length, then channel efficiency 'i' is:

(a) $\frac{1}{1+\frac{2Le}{BCF}}$ (b) $\frac{B}{B+\frac{2Le}{CF}}$

(c) $\frac{1}{1+\frac{2eLB}{CF}}$ (d) None

02. A 100 Km long cable has data rate 1.536 Mbps. The propagation speed in the cable is 2/3 of the speed of light. How many bits fit in the cable?

(a) 768 (b) 770

(c) 100 (d) 717

03. Suppose the round trip propagation delay for 100 Mbps Ethernet has 24.2μs. The network has 48 bit jamming signal then what is minimum frame size?

(a) 4640 (b) 2420

(c) 242 (d) 464

04. Consider a MAN with average source and destination 20 KM apart and one way delay of 100 μs. At what data rate the transmission delay is equal to two times of propagation delay.

(a) 50 Mbps (b) 60 Mbps

(c) 20 Mbps (d) None of these

05. The minimum frame size in CSMA/CD network is 48 bytes and channel data rate is 10^9 bits/sec. What will be the approximate propagation delay?

(a) 2 sec (b) 0.2 sec

(c) 0.2 μ sec (d) 2 μ sec

06. Nodes A and B are on the same 10 Mbps Ethernet segment, and the propagation delay between two nodes is 225 bit times. Suppose A and B send frames at t = 0, the frames collide then at what time do they (A or B) finish transmitting a jam signal. Assume a 48 bit jam signal.

(a) 225 bit times (b) 273 bit times

(c) 450 bit times (d) 57 bit times

07. Let A and B be two stations attempting to transmit on Ethernet. Each has a steady queue of frames ready to send. A's frames will be numbered A_1, A_2 and so on, and B's similarly. Let T = 51.2 μs be the exponential backoff base unit. Suppose A and B simultaneously attempt to send frame 1, collide, and happen to choose backoff times 0xT and 1xT, respectively, meaning 'A' wins the race and transmits A_1, while B waits. At the end of this transmission, B will attempt to transmit B, while A will attempt to transmit A_2. These first attempts will collide, but now A backs off for either 0xT or 1xT while B backs off for time equal to one of 0xT.....3xT. Give the probability that A wins the second backoff race.

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(a) 5/8 (b) 2/8
(c) 3/8 (d) 4/8

08. Suppose that 'N' Ethernet stations, all trying to send at the same time, require N/2 slot times to sort out who transmits next. Assuming the average packet size is 5 slot times; express the available bandwidth as a function of N.
(a) 5 / (N+10) (b) 10 / N
(c) 10 / (10+N) (d) 10 / (5 + N)

09. What is the maximum theoretical percent utilization in a 802.3 LAN (that uses 10 base 5 cable) with 128 stations connected to give 500 meter segments. Assume the frame size is 256 bytes and standard slot time is 51.2 μsec.
(a) 70% (b) 90% (c) 80% (d) 60%

10. Consider CSMA/CD topology, where propagation delay is 1 μsec, transmission delay is 5 μ sec, what is the throughput?
(a) 54% (b) 64% (c) 47% (d) 34%

Common data for Q11 to Q12 are given below. Solve the problems and choose correct answer

A communication link provides 1 Mbps for communication between the earth and the moon. The link is used to send color images from the moon. Each image consists of 10000 × 10000 pixels, and 16 bits are used for each of the three color components of each pixel

11. The number of images that can be transmitted per second is
(a) 2.1×10^4 (b) 2.08×10^{-4}
(c) 10×10^4 (d) 10×10^{-4}

12. If each image is transmitted as a single block, how long it takes to get an acknowledgement back from earth? The distance between earth and the moon is approximately 3,75,000 Km. assume $v = 3 \times 10^8$ m/sec
(a) 1000 sec/image (b) 2800 sec/image
(c) 4800 sec/image (d) 3800 sec/image

13. Which of the below characteristics is most basic to a LAN?
(a) Type – Bus, Ring or star topology etc
(b) Bit rate – 1 Mbps, 100 Mbps etc
(c) Addressing – Flat, Hierarchical etc
(d) Geographical extent – 100 meters, 2500 meters etc.

14. Suppose that N Ethernet stations, all trying to send at the same time, require 3 slot times to sort out who transmit next. Assume average packet size is 6 slot times, what would be the throughput of the Ethernet.
(a) 50% (b) 60% (c) 100 % (d) 66%

15. If WAN link is 2 megabits per second (Mbps) and RTT between source and destination is 300 msec, what would be the optimal TCP window size needed to fully utilize the line?
(a) 60,000 bits (b) 75,000 bytes
(c) 75,000 bits (d) 60,000 bytes

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16. Suppose that a group of 10 stations is serviced by an Ethernet LAN. How much bandwidth is available to each station if 10 stations are connected to 10 Mbps Ethernet hub and to 10 Mbps Ethernet switch
    (a) 10 Mbps are shared equally by the 10 stations in both hub and switch network
    (b) Each station has full access to the 10 Mbps in both hub and switch network.
    (c) Each station has full access to the 10Mbps in hub network and 10 Mbps are shared by 10 stations in switch network
    (d) Each station has nearly 10 Mbps to the Ethernet switch, each station has full access to the 10 Mbps if the switch capacity can handle the aggregate rate from all the stations.

17. A 1 KM long CSMA/CD with a propagation delay 5μsec has 10Mbps bandwidth. Repeaters are not allowed in the system. Data bits of 224, header bits of 32 bits are in packet. One slot time is reserved for the sender to start its transmission and another slot time is reserved for the receiver to capture the channel to send 32 bit acknowledgement frame. What is the effective data rate?
    (a) 1.89 Mbps (b) 6.92 Mbps
    (c) 9.03 Mbps (d) 4.66 Mbps

18. For a 10 Mbps Ethernet with 100 stations connected to it has 50 % efficiency. Velocity of propagation is 2.1×10^8 m/sec. Find the ratio of transmission to propagation delay.
    (a) 6.44 (b) 6.44
    (c) 5.44 (d) 0.5

19. If 4 cycles are used to represent a bit, and then what is the baud rate of the standard 10 Mbps Ethernet.
    (a) 20 mega baud (b) 40 mega baud
    (c) 2.5 mega baud (d) 5 mega baud

20. A 3000km long trunk operates at 1.536 Mbps is used to transmit 64 byte frames. If the propagation speed is 6 μsec/km, how many bits should the sequence numbers be?
    (a) 10 bits (b) 5 bits
    (c) 8 bits (d) 7 bits

21. If the time elapsed between sending the first frame and receiving the first acknowledgement is $2 \times (T + F/R + D/S)$ then find the distance between sender and receiver, If the time elapsed between sending the first frame and receiving the first acknowledgement is equal to the time to build and send **W** frames. The values given are S=200, W=4, T=1, F=200, R=10.Calculate the value of D.
    (a) 4200 mtrs (b) 3200 mtrs
    (c) 2100 mtrs (d) 8400 mtrs

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22. What could be the maximum distance between two extreme stations? For a minimum packet size of 1000 bits in Ethernet that operates with 10 base 2 cable and velocity of propagation is 2×10^8 m/sec

(a) 1000 KM (b) 10000 m
(c) 10 KM (d) 10000 KM

23. Consider a 10 Mbps Ethernet LAN that has stations attached to a 2.5 Km long coaxial cable. Given that the transmission speed is 2.3×10^8 m/s and packet size is 128 bytes, then find transmission delay for the packet?

(a) 102.4 μ sec (b) 10.24μ sec
(c) 1.024 μ sec (d) 0.1024 μ sec

24. Consider an Ethernet that operates with 2.5 km long coaxial cable. The propagation delay for the link is 10.9 μsec and transmission delay for the data packet to such a link is 102.4 μ sec, and then find the throughput of the Ethernet.

(a) 100 % (b) 50 %
(c) 69 % (d) 63 %

25. Find the minimum size of the packet in 1500 meters length of CSMA/CD with a data rate of 10^9 bits/sec. Assume velocity of propagation is 2.0×10^8 m/sec.

(a) 15000 bits (b) 7500 bits
(c) 750 bytes (d) 1000 bytes

26. If the propagation time is 10 ms and transmission time is 100 ms, then what is the efficiency of the Ethernet?

(a) 64.9% (b) 50%
(c) 75% (d) 25%

27. If Bandwidth × RTT is 25 packets, then what should be the sequence number space required in SR protocol.

(a) 50 bits (b) 6 bits
(c) 25 bits (d) 5 bits

28. Suppose two nodes, A and B are attached to opposite ends of the cable with propagation delay of 12.5 μs. Both nodes attempt to transmit at time t = 0. Frames collide and after first collision, A draws k = 0 and B draws k =1 in the exponential backoff protocol. If you consider the jam signal of 10 μs, then at what time they (A or B) finish transmitting a jam signal.

(a) 25 μs (b) 2.5μs (c) 12.5 μs (d) 22.5μs

Statement for Linked answer Q29 and Q30 is given below:

Suppose two nodes, A and B are attached to opposite ends of the cable with propagation delay of 10.0 μs. Both nodes attempt to transmit at time t = 0. Frames collide and after first collision, A draws k = 0 and B draws k = 1 in the exponential backoff protocol. Ignore the jam signal. Consider the bandwidth of the link is 10 Mbps and packet size is 500 bits.

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29. At what time (in seconds) is station A starts packet transmission, with respect to time t = 0.

(a) 10.0 μs (b) 20.0 μs

(c) 15.0 μs (d) 200 μs

30. At what time (in seconds) is A's packet completely delivered at A, with respect to time identified in the above problem (Q 29) i.e., how much time further packet takes to be delivered completely at B, once transmission starts at A.

(a) 100.0 μs (b) 90 μs

(c) 80 μs (d) 137.5 μs

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Solutions

01. Ans: (c)

Sol: Channel efficiency

$$= \frac{\text{Transmission period}}{\text{Transmission period} + \text{collision period}}$$

$$\text{Transmission Period} = \frac{\text{Frame length}}{\text{Channel capacity}}$$

$$= \frac{F}{B}$$

Collision period

= number of contention slots × slot duration

= e × 2 × propagation delay

$$\text{Propagation delay} = \frac{\text{cable length}}{\text{velocity}} = \frac{L}{C}$$

$$\text{Collision Period} = 2 \times e \times \frac{L}{C}$$

$$\text{Channel Efficiency} = \frac{\frac{F}{B}}{\frac{F}{B} + 2\frac{eL}{C}}$$

$$= \frac{F}{F + \frac{2eLB}{C}}$$

$$= \frac{1}{1 + \frac{2eLB}{CF}}$$

02. Ans: (a)

Sol: $\text{Propagaion speed} = \frac{2}{3} \times \text{light speed}$

$$= \frac{2}{3} \times 3 \times 10^8 \text{ m/s} = 2 \times 10^8 \text{ m/s}$$

$$\text{Propagation delay for 100KM} = \frac{100 \times 1000 \text{ m}}{2 \times 10^8 \text{ m/s}}$$

$$= 5 \times 10^{-4} \text{ sec}$$

Number of bits in the cable

$= 1.536 \times 10^6$ * Propagation delay

$= 1.536 \times 10^6 \times 5 \times 10^{-4}$ bits

= 768 bits

03. Ans: (b)

Sol: The frame size is minimum only when RTT

= Transmission delay

$$\text{Transmission delay} = \frac{L}{B}$$

$\Rightarrow B = 100$ Mbps $= 100 \times 10^6$ bps

RTT = 24.2 μs = 24.2×10^{-6} sec

$$24.2 \times 10^{-6} = \frac{L}{B}$$

$\Rightarrow L = 24.2 \times 10^{-6} * 100 \times 10^6$

= 2420 bits

04. Ans: (d)

Sol: Distance d = 20 KM

Propagation delay = 100 μs

Assume packet size = 1 KB

Transmission delay = 2 × propagation delay

$$\frac{\text{packet size}}{\text{Transmission rate}} = 2 \times 100 \mu s$$

$$\text{Transmission rate} = \frac{\text{packet size}}{2 \times 100 \mu s}$$

$$= \frac{1024 \times 8}{10^{-6} \times 2 \times 100} = 40 \text{ Mbps}$$

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05. Ans: (c)

Sol: Transmission delay $= \frac{48 \times 8}{10^9}$ sec $= 0.384\,\mu s$

RTT = Transmission delay

2 × propagation delay = Transmission delay

Propagation delay = 0.192 = 0.2 μs

06. Ans: (b)

Sol: Bandwidth (B) = 10 Mbps

Propagation delay = 255 bit times

Jam signal = 48 bits

At t= 0 A & B started transmission of frame

At $t = \frac{225}{2}$ There is a collision

At t = 225 A & B detects collision

At t = 225 + 48 = 273

A finishes the Jam signal

07. Ans: (a)

Sol: A can choose slots (0, 1)

B can choose (0, 1, 2, 3)

Number of slot assignments (A, B)

Where A succeeds: (0, 1), (0, 2), (0, 3), (1, 2), (1, 3)

For example: (1, 2) mean A picks 1 and B picks 2 and hence, A succeeds because 7 waits lesser amount of time.

The total number of assignments, including those are A fails

(0, 1), (0, 2), (0, 3), (1, 2), (1, 3), (1, 0), (1, 1), (0, 0)

[These assignment case A to fail]

Total: 8

Probability that A succeeds

$$= \frac{\text{number of Assignments where A succeeds}}{\text{Total number of possible assignments}}$$

$$= \frac{5}{8}$$

08. Ans: (c)

Sol: $$\text{Bandwidth} = \frac{\text{packet size}}{\text{packet size} + \text{time slots}}$$

$$= \frac{5}{5 + \frac{N}{2}} = \frac{10}{10 + N}$$

09. Ans: (a)

Sol: Utilization (U) = 100 * (F / R) / (F/R + T * C)

U = percentage of utilization,

R = transmission rate

F = Number of bits in a frame

T = Time slot

C = Number of contention Intervals

$= (1 - 1/N)^{1-N} - 1$

N = Number of stations = 128

Frame size = (256 * 8) bits = 2048 bits,

Data rate is 10 Mbps

F/R = 2048 bits/ 10 Mbps = 204.8 μsec

$C = (1 - 1/N)^{1-N} - 1 = (1 - 1/128)^{-127} - 1$

$= (0.992)^{-127} - 1$

$= 1.7$

U = (100 * 204.8)/(204.8 + 51.2 * 1.7)

= 20480 / 291.84

= 70.17 ≃ 70%

10. Ans: (c)

Sol:

$$\text{Throughput} = \frac{\text{Transmission delay}}{\text{Transmission delay} + 2 \times e \times \text{propagation delay}}$$

$$= \frac{5}{5 + 2 \times 2.718}$$

$$= \frac{5}{5 + 5.44}$$

$$= \frac{5}{10.44} = 47\%$$

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11. Ans: (b)

Sol: 3 colors 16 bits for each color

10000×10000 pixels

Number of images that can be transmitted per sec $= \dfrac{10^6}{10000 \times 10000 \times 16 \times 3}$

$= \dfrac{1}{4800} = 0.000208 = 2.08 \times 10^{-4}$

12. Ans: (c)

Sol: RTT

= Transmission Time + 2 × Propagation delay

$= \dfrac{L}{B} + 2 \times \dfrac{d}{V}$

$L = 10000 \times 10000 \times 16 \times 3$

$B = 1$Mpbs

$d = 3,75,000$ km $= 3,75,000 \times 10^3$ meters

$V = 3 \times 10^8$ m/sec

$= \dfrac{10000 \times 10000 \times 16 \times 3}{10^6} + \dfrac{2 \times 3,75,000 \times 10^3}{3 \times 10^8}$

$= 4800 + \dfrac{75}{30} = 4800 + 2.5$ sec

$= 4800$ sec.

13. Ans: (d)

Sol: LAN can be established over 100 meters, 2500 meters.

14. Ans: (d)

Sol: $\text{Throughput} = \dfrac{\text{Average Packet size}}{\text{Average packet size} + \text{Contention slots}}$

$= \dfrac{6}{6+3} = 66\%$

15. Ans: (b)

Sol: Link capacity = 2 Mbps $= 2 \times 10^6$ bps

RTT = 300 msec

To fully utilize the link

1 sec $\rightarrow 2 \times 10^6$ bits

300×10^{-3} sec $\rightarrow$ x ?

$x = 2 \times 10^6 \times 300 \times 10^{-3}$ bits

= 6,00, 000 bits

= 75, 000 bytes

16. Ans: (d)

Sol: The bandwidth of Hub is equally shared by 10 stations and all stations can access 10 Mbps switch fully.

17. Ans: (d)

Sol: T_P (propagation delay) = 5 μsec;

1. One slot time (sender) = $2\tau = 2T_p = 10$ μsec

2. T_x (transmission delay) in data

$= \dfrac{224+32}{10 \times 10^6} = 25.6$ μsec

3. One slot time (receiver) = 10 μsec

$T_{x_{ACK}} = 32/10$ Mbps $= 3.2$ μsec

$\text{Effective data rate} = \dfrac{224}{(10+25.6+10+3.2)\mu\text{sec}}$

= 4.59 Mbps

≃ 4.6 Mbps (approx)

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18. Ans: (c)

Sol: Data rate B = 10 Mbps

Propagation speed $V = 2.1 \times 10^8$ m/sec

$$\text{efficiency} = \frac{\text{Transmission delay}}{\text{Transmission delay} + 2 \times c \times \text{propagation delay}}$$

$$= \frac{1}{1 + 5.44 \times \frac{\text{propagation delay}}{\text{Transimission delay}}}$$

$$\frac{50}{100} = \frac{1}{1 + 5.44 \times \frac{\text{propagation delay}}{\text{Transmission delay}}}$$

$$\Rightarrow 1 + 5.44 \times \frac{\text{propagation delay}}{\text{Transmission delay}} = 2$$

$$\frac{\text{Propagation delay}}{\text{Transmission delay}} = \frac{1}{5.44}$$

$$\frac{\text{Trasmission delay}}{\text{propagation delay}} = 5.44$$

19. Ans: (b)

Sol: baud rate = number of cycles * bit rate

= 4 * 10 Mbps

= 40 Mega baud

20. Ans: (d)

Sol: L = 64 × 8 bits

Distance d = 3000 km

Propagation speed for 3000Km = 18000μs

RTT = 2 * Propagation delay = 36000 μs

$B = 1.536 \times 10^6$ bps

1 sec → 1.536×10^6 bits

36×10^{-3} sec → ?

Number of bits = $1.536 \times 36 \times 10^3 = 55296$

Sequence number

$$= \frac{55296}{\text{Packet size}} = \frac{55296}{64 \times 8} = 108$$

$2^K = 108 \Rightarrow K = 7$ bits

21. Ans: (a)

Sol: $2 * \left(T + \frac{F}{R} + \frac{D}{S}\right) = W * (T + F/R)$

$$\frac{D}{S} = \frac{W}{2}\left(T + \frac{F}{R}\right) - \left(T + \frac{F}{R}\right)$$

$$\frac{D}{S} = \frac{(W-2)}{2}\left(T + \frac{F}{R}\right)$$

$$D = \frac{S(W-2)}{2}\left(T + \frac{F}{R}\right)$$

$$= 200\left(\frac{4-2}{2}\right)\left(1 + \frac{200}{10}\right)$$

$$= 200\frac{(210)}{10} = 4200 \text{ mtrs}$$

22. Ans: (b)

Sol: Use Transmission delay = RTT

L/B = 2 * (d/v)

23. Ans: (a)

Sol: $\text{Transmission Delay} = \frac{\text{packet size}}{\text{capacity}}$

$$= \frac{128 \times 8}{10 \times 10^6} \text{ sec} = 102.4\ \mu \text{ sec.}$$

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24. Ans: (d)

Sol: Transmission delay (TD) = 102.4 μ sec

Propagation delay (PD) = 10.9 μ sec

$$\text{Through put} = \frac{T.D}{T.D + 2 \times e \times P.D}$$

$$= \frac{102.4}{102.4 + 2 \times 2.718 \times 10.9} = \frac{102.4}{161.524}$$

$$= 63\%$$

25. Ans: (b)

Sol: $T_x = 2T_p$

$$\Rightarrow \frac{L_{min}}{B} = 2 \times \frac{d}{S}$$

$$L_{min} = \frac{2 \times d \times B}{S}$$

$$= \frac{2 \times 10^9 \times 1500}{2 \times 10^8}$$

$= 2 \times 7500$ bits

$= 15000$ bits

26. Ans: (a)

Channel Efficiency

$$= \frac{\text{Transmission Period}}{\text{Transmission Period} + \text{Contention Period}}$$

Contention Period

= number of content slots * 2 * propagation time

= 2 * e * 10 ms

= 2 * 2.718 * 10= 54.36 ms

$$\text{Channel Efficiency} = \frac{100\text{ms}}{100 + 54.36\text{ms}}$$

$= 0.649 = 64.9\%$

27. Ans: (b)

Sol: Bandwidth × RTT = 25 packets

$$w_s = \frac{N}{2}$$

$N = 50$

$2^K = 50 \Rightarrow K = 6$ bits

28. Ans: (d)

Sol: At t = 0 A & B started the communication

At $t = \frac{12.5}{2}$ μsec there is collision

At t = 12.5 μsec, A & B knows the collision through propagation.

Either A or B transmits jam signal

At t = 12.5 + 10 μsec either A or B finishes the jam signal = 22.5 μsec

29. Ans: (b)

Sol: At t = 0, A & B start to transmit its frames.

At t = 10.0 μs/2 collision happens

At t = 10/2 + 10/2 = 10 μsec, A & B detects collisions

Now A draws k = 0, it should send the frame immediately. But A must wait 1 T_P (propagation delay) to allow the link to be cleared.

t = 10 + 10 = 20 μsec

A starts to send its frame

30. Ans: (c)

Sol: At t = 0, A & B Attempts to transmit

At t = 5 μsec, there is collision

At t = 10 μsec, either A or B detects the collision

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Now A draws k = 0

At t = 20 μ sec, A starts packet transmission.

$$\text{Transmission time} = \frac{500}{10 \times 10^6} \text{ sec}$$

$$= 50\ \mu\text{sec}$$

The time that the A's packet takes for complete delivers at B.

= A's start time + propagation delay + Transmission time

= 20 + 10 + 50

= 80 μ sec

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Chapter 3 Data Link Layer (Flow Control, Error Control)

01. Sliding window protocol is used by
(a) Connectionless protocols
(b) Connection oriented protocols
(c) Datagram oriented circuits
(d) Circuit switching

02. If 'N' is the maximum sequence number, then the window size in GBN & SR is:
(a) N/2, N – 1
(b) N, (N+1)/2
(c) (N + 1) / 2, N.
(d) N – 1, N/2

03. If the packet size is 1 KB and channel capacity is 10^9 bits/sec, what is the transmission time?
(a) 6 μs
(b) 10 μs
(c) 8 μs
(d) cannot be calculated

04. Consider the Stop and Wait protocol, if transmission time is 'a' at the source and propagation delay is 'b', then after what time, the sender can send the second packet? Consider data packet and ACK packet of the same size.
(a) 2a + 2b
(b) (a + b)/2
(c) 2b + a
(d) a + 2b

05. To reach 100 % utilization, transmitter should be able to transmit frames continuously during round trip propagation time. Suppose if 'N' frames are transmitted in one RTT, then what is the minimum sequence field size?
(a) N
(b) (N+1) / 2
(c) N / 2
(d) $\log_2 N$

06. Three possible strategies for sending ACK frames in a Go-Back-N setting are as follows:
(a) Send an ACK frame immediately after each frame is received.
(b) Send an ACK frame after every other frame is received.
(c) Send an ACK frame when the next piggybacking opportunity arises.
(d) None of the above

07. Match the following and choose the correct combination:

P : Stop & Wait	1. Receives out of order packets
Q : GBN	2. Used in connection oriented communication
R : SR	3. Sends only one packet at a time
S : SWP	4. Used in connectionless communication
	5. Receives only one packet at a time

(a) P-3,Q-5,R-1,S-2
(b) P-1,Q-3,R-4,S-2
(c) P-1,Q-2,R-3,S-4
(d) P-3,Q-1,R-5,S-4

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08. Suppose you are designing a SWP for a 1-Mbps point to point link to a stationary satellite revolving around the earth at 3×10^4 km altitude. Assume that each frame carries 1 KB of data and speed of light is 3×10^8 m/s. What is the minimum number of bits you need for the sequence numbers if RWS=1?

(a) 25 bits (b) 15 bits
(c) 5 bits (d) 26 bits

Data for Q09 & Q10 given below solve the problems and choose correct answer:

A 64 Kb packet message is to be transmitted from the source to the destination with 2000 m apart. The network limits packet to a 2 Kb and each packet has 32 byte header. The transmission lines in the network have a bit error rate of 10^{-6} and bandwidth is 1.5 Mbps. Stop & wait ARQ is used in each transmission line. Assume the signal propagates at a speed of 2×10^5 km/sec.

09. How long does it take on the average to get the message from source to the destination?

(a) 1 sec (b) 0.7 sec
(c) 1.7 sec (d) 2.7 sec

10. If senders window size(W_s) is 75. What will be sequence numbers required in Go-Back-N and SR protocol?

(a) 0 to 75 and 0 to 76
(b) 0 to 75 and 0 to 149
(c) 0 to 75 and 0 to 150
(d) 0 to 74 and 0 to 150

11. Consider transmission delay for the packet as 2 ms, propagation delay between client and server is 30 ms. If sender's window size is 10 then what is the ideal period for the sender in each cycle.

(a) 30 ms (b) 10 ms
(c) 20 ms (d) 40 ms

12. Consider the Go-Back-N protocol, what can go wrong if the ACK timer is ***not*** used?

(a) The ACK must be sent immediately, means that never use piggybacking
(b) The ACK must only be sent if it can be piggybacked
(c) Either option (a) or (b) are the two options that we can use
(d) If ACK timer is not used, then communication not possible.

13. In SR protocol, the condition $W_s \leq (MaxSeqNum + 1) / 2$ holds good only when

i. $W_s > W_R$
ii. $W_s = W_R$
iii. $W_s < W_R$
iv. Always it is applicable

(a) i, iii are correct
(b) ii, iv are correct
(c) ii alone is correct
(d) None of the above

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14. Consider source and destination in a 10 Mbps network with sender window has 5 packets. Transmission delay for a packet is 10 μsec, propagation delay from source to destination is 250 μ sec. How long sender is ideal once a window is transmitted before being starting second window? Assume ACK transmission time is negligible.
(a) 250 μ sec (b) 400 μ sec
(c) 450 μ sec (d) 150 μ sec

15. If Bandwidth × RTT is 25 packets, then what should be the sequence number space required in GBN protocol.
(a) 50 bits (b) 6 bits
(c) 25 bits (d) 5 bits

16. Assume a system with fixed-length 250-byte packets where each packet contains 25 bytes of headers and trailers (thus, the data payload is 225 bytes). For a 600 byte message, what is the % utilization in this system?
(a) 60 % (b) 70 %
(c) 90% (d) 88%

For Questions Q.17 and Q.18 use the following description:

Suppose you are designing a SWP for a 1-Mbps point to point link to a stationary satellite revolving around the earth at 3×10^4 km altitude. Assume that each frame carries 1 KB of data and speed of light is 3×10^8 m/s.

17. What is the minimum number of bits you need for the sequence numbers if RWS=1
(a) 15 bits (b) 25 bits
(c) 5 bits (d) 26 bits

18. What is the minimum number of sequence numbers required if RWS= SWS.
(a) 25 Seq Num (b) 50 Seq Num
(c) 26 Seq Num (d) 45 Seq Num

19. Frames of 1000 bits are sent over a 1 Mbps link between earth and moon whose propagation delay is 270 msec. Headers are very short and acknowledgements are always piggybacked on to data frames. Three bit sequence numbers are used. What is the maximum achievable channel utilization in
(i) Stop and wait protocol
(ii) GBN protocol
(iii) SR protocol
(a) 0.18 %, 1.29%, 1.74%
(b) 0.18 %, 1.29%, 0.74%
(c) 0.18 %, 0.29%, 1.74%
(d) 0.74%, 1.29%, 0.18%

20. If S_u and S_l are the upper and lower ends of the sender's window and R_u and R_l are the upper and lower ends of the receiver's window, then which of the following relation does ***not*** holds good?
(a) $0 <= S_u - S_l + 1 <= W$
(b) $R_u - R_l + 1 = W$
(c) $S_l <= R_l <= S_u + 1$
(d) $S_l + S_u <= R_l$

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21. In GBN protocol, what will be the maximum senders window size if four bit sequence field is used?
(a) 8 (b) 15
(c) 14 (d) 16

22. Suppose you are designing a sliding window protocol for a 1 – Mbps point to point link to the moon, which has a one way latency (delay) of 1.25 seconds. Assuming that each frame carries 1 KB of data, what is the min. number of bits you need for the sequence number?
(a) 7 bits (b) 14 bits
(c) 21 bits (d) 28 bits

23. A bulk data transfer application where a server sends large file that is segmented in a number of full size packets that are to be transferred to the client. Which one of the strategies for sending ACK frames in a GO-back-N setting is feasible if channel has a low probability of error?
(a) Send an ACK frame after every other frame is received.
(b) Send an ACK frame immediately after each frame is received
(c) Piggyback method
(d) None of the above

For Question No. 24 there are two statements Assertion (a) and Reason (r). Choose:

(a) Both (A) and (R) are true and (R) is the correct reason for (A).
(b) Both (A) and (R) are true and (R) is not the correct reason for (A).
(c) Both (A) and (R) are false.
(d) (A) is true but (R) is false.

24. **Assertion (A):** Selective repeat protocol requires more sequence numbers than Go-back-N protocol.
Reason (R): Selective repeat protocol uses independent acknowledgements.

25. If round trip delay (RTT) is 100 micro seconds, bandwidth is 10 Mbps, throughput in SWP for a window size of 100 bits is ____Mbps.

26. With 4 bit sequence field in selective repeat protocol, can we have $W_s = 15$, $W_r = 1$?
(a) Yes (b) No
(c) Cannot say (d) insufficient data

27. Throughput of sliding window protocol is 10 Mbps, what would be the window size if RTT is 100 micro seconds?
(a) 1000 bits
(b) 1000 bytes
(c) 100 bits
(d) 100 bytes

28. Station A uses 64 by
messages to station
propagation delay be
milliseconds and the
between A and B is
optimal window size
(a) 40
(c) 80

29. The maximum w
transmission using
with 8–bit frame sec
(a) 2^8
(c) 2^8-1

30. Consider the Go
sender's window
time t, the next
receiver is expect
of k. Assume t
reorder messages
of sequence nu
window at time
receives ACK.

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28. Station A uses 64 byte packets to transmit messages to station B using SWP. The propagation delay between A and B is 40 milliseconds and the bandwidth on the path between A and B is 256 Kbps. What is the optimal window size that A should use?

(a) 40 (b) 160
(c) 80 (d) 20

29. The maximum window size for data transmission using selective repeat protocol with 8–bit frame sequence number is

(a) 2^8 (b) 2^7
(c) 2^8-1 (d) 2^6

30. Consider the Go-back-n protocol with a sender's window size 'n'. Suppose that at time t, the next in order packet that the receiver is expecting has a sequence number of k. Assume that the medium does not reorder messages. What are the possible sets of sequence numbers inside the sender's window at time t. Assume the sender already receives ACK.

(a) [k–1, k+n–1] (b) [k, k+n–1]
(c) [k, k+n] (d) [k+n, k–1]

31. Consider three nodes A, B, C connected in series. Node A is connected to node B via a 3Gbps fiber optic link, 500km in length. Node B is connected to node C via 60 Mbps link, 15 km in length. The links are full duplex. The rate of transmission errors on the links, the switching time at B, and the time to transmit an ACK are all negligible and can be ignored. A large file is to be sent from node A to node C, and there is no other traffic on the links. Packets are 1024B, including headers. Suppose an end–to–end sliding window protocol is used with SWS = RWS.
What is the optimal value for SWS?

(a) 39 packets (b) 49 packets
(c) 69 packets (d) 79 packets

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Solutions

01. Ans: (b)

Sol: Sliding window protocol is used by connection oriented protocols like PPP, HDLC, TCP protocols.

02. Ans: (b)

Sol: In GBN senders window size

= maximum sequence number (N)

In selective repeat the window size

$$= \frac{N+1}{2}$$

where N is maximum sequence number

03. Ans: (c)

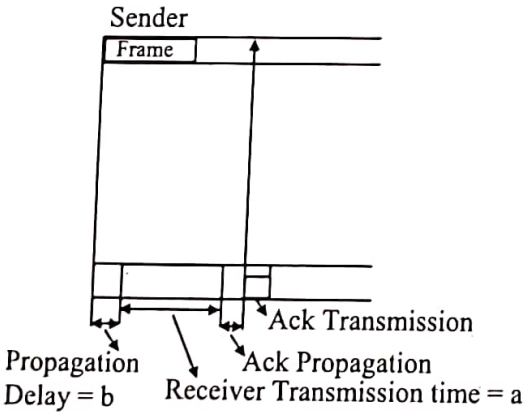
Sol: $\text{Transmission Time} = \frac{\text{Packet size}}{\text{Channel capacity}}$

$$= \frac{1\text{kB}}{10^9\ \text{b/s}} = \frac{10^3 * 8}{10^9}\text{sec}$$

$$= 8 * 10^{-6}\text{sec} = 8\ \mu\text{s}$$

04. Ans: (a)

Sol:



The Time to send second packet

= packet propagation delay

+ packet Transmission time

+ Ack propagation delay

+ Ack transmission time.

= 2a + 2b

05. Ans: (d)

Sol: $2^k = N$

Where

k = Number of bits in sequence number

N is number of frames transmitted

$k = \log_2 N$

06. Ans:(c)

Sol: In an interactive application piggy backing is the perfect choice.

07. Ans: (a)

Sol: Stop & wait → sender, one packet waits for Ack, after receiving Ack it sends

GBN → Ensures inorder → Receives one packet at a time.

SR → No order of packet at receiving end

SWP → Connection Oriented Communication

08. Ans: (c)

Sol: Capacity B = 1 Mbps = 10^6 bps

Distance d = 3×10^4 km = $3 \times 10^4 \times 10^3$m

Speed v = 3×10^8 m/s

$$\text{Propagation delay} = \frac{3\times10^4\times10^3}{3\times10^8} = 0.1\text{sec}$$

RTT = 2 * Propagation delay = 0.2 sec

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1 sec → 10^6 bits

0.2 sec → ?

No. of bits = 0.2×10^6 bits

Packet size L = 1KB = 1024×8bits

$$\text{Sequence number} = \frac{0.2\times10^6}{1024\times8} = 24\text{sec}$$

$2^K = 24$; K = 5 bits

09. Ans: (b)

Sol: Distance d = 2000 m

Propagation speed v = 2×10^5 m/sec (Assume)

$$\text{Propagation delay} = \frac{2000}{2\times10^5}\text{sec} = 0.01 \text{ sec}$$

$$\text{Transmission time} = \frac{\text{Packet Size}}{\text{Capacity}}$$

$$= \frac{2048\times8}{1.5\times10^6} = 0.0109$$

Total time

= Propagation time + Transmission time

= 0.0209 sec

probability of error in the packet = 0.01776

total time per packet = total time / (1 – p)

= 0.0212

$$\text{Number of packets} = \frac{64\text{Kb}}{(2\text{Kb}-32\text{b})}$$

$$= \frac{65536}{2016} = 33 \text{ (Aprox)}$$

33 packets = 33 × 0.0212 = 0.7 sec

10. Ans: (b)

Sol: **Go – Back – N**

Maximum sequence number = W_s = 75

Sequence numbers are 0 to 75

Selective Repeat

Assume N is maximum sequence number then

$$W_s = \frac{N+1}{2} \Rightarrow N = 149$$

Sequence numbers are 0 to 149

11. Ans: (d)

Sol: Transmission delay for the packet = 2 ms

Propagation delay between client and server = 30 ms

Sender's window size = 10

Transmission delay / 10 packets = 20 ms

RTT = 2 * propagation delay = 60 ms

The ideal period = 60 – 20 ms = 40 ms

12. Ans: (c)

13. Ans: (b)

Sol: When $W_s = W_R$ then

$$\text{SWS} = \text{RWS} = \frac{N+1}{2}$$

where N is maximum sequence number.

14. Ans: (b)

Sol: Transmission delay for packet = 10 μsec

Transmission delay for window = 5 × 10 = 50 μsec

Ideal Time

= 2 × (propagation delay – Transmission delay for window)

= 400 μsec

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15. Ans: (d)

Sol: 25 packets requires 5 bits for sequence number ($2^5 = 32$)

16. Ans: (d)

Sol: 600 bytes message fragment into 225 + 225 + 150 bytes for each fragment 25 bytes header.

Overhead = 75 bytes

$$\%\text{Utilization} = \frac{600}{675} = 88\%$$

17. Ans: (c)

Sol: Packet size L = 1 KB = $10^3 \times 8$ bits, Bandwidth B = 10^6 bits/sec

$$\text{propagation delay} = \frac{\text{Altitude}}{\text{propagation speed}}$$

$$= \frac{3\times10^4 \text{ km}}{3\times10^8 \text{ m/s}}$$

$$= \frac{3\times1000\times10^4}{3\times10^8}\text{sec} = 0.1$$

RTT = 2 * propagation delay

= 0.2 sec

1 sec → 10^6 bits

0.2 sec → ?

$$\text{sequence number} = \frac{0.2\times10^6}{10^3\times8} = 25$$

$2^k = 25 \Rightarrow k = 5$ bits

18. Ans: (b)

Sol: From question 17 minimum number of sequence numbers = 25

When RWS = SWS

$$SWS < \frac{(\text{max_seq_num}+1)}{2}$$

$$\text{Max_seq_num} > 2\times SWS - 1$$

$$> 2\times24 - 1 = 47$$

Therefore, answer is 50 since 50 > 47 is the minimum value that satisfies the condition among all choices.

19. Ans: (b)

Sol: RTT = 2* propagation delay = 2 × 270

= 540 msec

(i) Stop and wait

$$\text{channel utilization} = \frac{\text{Transmission delay}}{\text{Tranmission delay} + \text{RTT}}$$

$$\text{Transmission delay} = \frac{1000}{10^6} = 1\text{msec}$$

$$\text{Channel utilization} = \frac{1}{1+540} = \frac{1}{541} = 0.18\%$$

(ii) GBN protocol

Maximum sequence number = 7

$$\text{Channel utilization} = \frac{7}{540} = 1.29\%$$

(iii) Selective repeat

$$\text{Sender window size} = \frac{\text{max.sequnce}+1}{2} = 4$$

$$\text{Channel utilization} = \frac{4}{540} = 0.74\%$$

20. Ans: (d)

Sol: a, b and c are true

$S_l + S_U \nleq R_l \Rightarrow$ sender window size cannot be less than or equal to lower end of the receiver's window.

21. Ans: (b)

Sol: Maximum window size

= maximum sequence number

= 15 because the sequence number starts from 0

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22. **Ans: (a)**

Sol: RTT = 2.5 sec

1 sec → 10^6 bits

2.5 sec → x

$x = 2.5 \times 10^6$

sequence Number = $\frac{2.5 \times 10^6}{10^3 \times 8} = 312$

⇒ 7 bits

23. **Ans: (a)**

Sol: If channel has low probability of error then option (a) is best

If channel has high probability of error then option (b) is best

24. **Ans: (b)**

Sol: (A) and (R) are true but there is no relation

25. **Ans: 1**

Sol: Throughput=one window (in bits) size/ RTT

= 100 bits/100 micro seconds

= 1 Mbps.

26. **Ans: (a) & (d)**

Sol: Though total sequence numbers are <= 2, 4 but $W_r = 1$ will not allow in selective repeat protocol to receive out of order packets hence it behaves like GBN.

27. **Ans: (b)**

Sol: Throughput = one window size /RTT

28. **Ans: (a)**

Sol: RTT = 2* propagation delay = 80 msec

Packet size = 64 × 8 = 512 bits

Bandwidth B = 256 Kbps

Optimal window size in terms of bits

$B * RTT = 256 \times 10^3 * 80 \times 10^{-3}$

$= 256*80$

Window size in packets $= \frac{256*80}{512} = 40$

29. **Ans: (b)**

Sol: SWS + RWS = 2^n if SWS = RWS

Then maximum window size = 2^{n-1}

$= 2^{8-1} = 2^7$

30. **Ans: (b)**

Sol: For example consider sender's window size as 3 and transfers 3 packets (0,1,2), receiver receives all of them, therefore next in order packet receiver expecting is 3. So k=3. If acknowledgments are received by sender then it moves its window to 3, 4, 5. It is k (3) to k+n-1 (3+3–1=5). It is true for all window sizes.

31. **Ans: (a)**

Sol: RTT= Transmission time + 2*Propagation delay

$= \frac{8192}{3 \times 10^9} + \frac{8192}{60 \times 10^6} + 2\left(\frac{500 \times 10^3}{2 \times 10^8} + \frac{15 \times 10^3}{2 \times 10^8}\right)$

=(0.00273 ms+0.1365 ms)+2*(2.5+0.075) ms

= 5.28923 ms

The bottle neck link decides the number of packets that can be sent

= delay × bandwidth

= 5.28 × 60 Mbps

= 38.79 packets

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Chapter 4 Network Layer (IPv4, IPv6)

01. Class B network on the internet as a subnet mask of 255.255.240.0. What is the maximum number of hosts per subnet?
(Assuming Classfull addressing scheme is followed.)
(a) 5094 (b) 4094
(c) 3094 (d) 1024

02. An organization has a class C network and wants to form subnets for four departments, with hosts as follows.

A	72
B	35
C	20
D	18 hosts

What is the possible arrangement of subnet maskes?
(Assuming Classfull addressing scheme is followed.)
(a) For A 255.255.255.128 &
For B 255.255.255.192 &
For C & D 255.255.255.223
(b) For A 255.255.255.223,
For B 255.255.255.192 &
For C & D 255.255.255.128
(c) For A 255.255.255.192 &
For B 255.255.255.128 &
For C & D 255.255.255.223
(d) For A & B 255.255.255.223
For C & D 255.255.255.223

03. Assume that the IP address is 108.77.51.70 and subnet mask is 255.255.128.0 what is the subnet number and host number?
(Assuming Classfull addressing scheme is followed.)
(a) 108.77.0.0 and 0.0.51.70
(b) 0.0.51.70 and 108.77.0.0
(c) 0.77.0.0 and 0.0.51.70
(d) 0.0.51.70 and 0.77.0.0

04. IP currently uses 32-bit addresses, if we could re–design IP to use the 6-bytes MAC address instead of the 32-bit addresses, what is true about the system?
(a) Allows IP addresses to be dynamically allocated when the hardware moves to the different network.
(b) Mapping is necessary to enable indirection from IP address to the MAC address.
(c) As we use static IP addresses, routing will be much less efficient.
(d) No effect on the system.

05. Which one of the following IP addresses belongs to private host address.
(Assuming Classfull addressing scheme is followed.)
(a) 200.200.200.89 (b) 127.1.1.1
(c) 10.1.1.1 (d) 255.255.255.255

06. Match the
combination:
(Assuming Cla
followed.)

P : 127.1.1.1
Q: 255.255.255.2
R : 10.0.0.0
S : 0.0.0.100

(a) P-4, Q-3,
(b) P-2, Q-3,
(c) P-4, Q-3,
(d) P-2, Q-1,

07. An ISP use
minimize r
entries, one
205.100.0.0
address 2
address?
(a) 205.100
(c) 205.100

08. An organi
wants to
with hosts
A
B
C
D

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06. Match the following with correct combination:
(Assuming Classfull addressing scheme is followed.)

P : 127.1.1.1	1. This network address
Q: 255.255.255.255	2. Directed broadcasting address
R : 10.0.0.0	3. Limited broadcasting address
S : 0.0.0.100	4. Loop back address
	5. Can be used as S.IP and D.IP address

(a) P-4, Q-3, R-1, S-5
(b) P-2, Q-3, R-1, S-5
(c) P-4, Q-3, R-1, S-2
(d) P-2, Q-1, R-3, S-4

07. An ISP uses supernet (CIDR) principle to minimize routing table entries, it has two entries, one is 205.100.0.0/22 another one is 205.100.0.0/20. A packet with destination address 205.100.1.1 uses which CIDR address?
(a) 205.100.0.1/22 (b) 205.100.0.0/20
(c) 205.100.0.0/21 (d) 205.100.0.0/22

08. An organization has a class C network and wants to form subnets for four departments, with hosts as follows :

A 58
B 35
C 20
D 18

What is the possible arrangement of subnet masks?
(Assuming Classfull addressing scheme is followed.)
(a) 255.255.255.128
(b) 255.255.255.224
(c) 255.255.255.192
(d) 255.255.255.1

09. If the university has 35 departments and uses class B address, If use 6 bit subnet number and 10 bit host number then how many Ethernets and maximum hosts in each Ethernet possible?
(Assuming Classfull addressing scheme is followed.)
(a) 64, 256 (b) 64, 254
(c) 64, 0 (d) 64, 1022

10. The number of usable subnet and host addresses per subnet for the subnet mask 255.255.255.128 to the class B address
(Assuming Classfull addressing scheme is followed.)
(a) 254, 256 (b) 512, 126
(c) 126, 512 (d) None of these

11. How many hosts can be connected in a network with 255.255.252.0 as subnet mask?
(Assuming Classfull addressing scheme is followed.)
(a) 1022 (b) 254
(c) 1024 (d) 2028

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12. In a network with address 200.1.0/19, what would be the maximum number of systems possible?
(a) 2^{11} (b) 2^{13} (c) 2^{8} (d) 2^{19}

13. In a class B find which one of the below subnet mask is incorrect. The network has 200 subnets and 225 hosts in each subnet.
(Assuming Classfull addressing scheme is followed.)
(a) 255.255.255.0 (b) 255.255.240.240
(c) 255.255.192.252 (d) 255.255.0.0

14. How many bits are allocated for HID in 173.250.10.1 address?
(Assuming Classfull addressing scheme is followed.)
(a) 24 (b) 16
(c) 8 (d) None of these

15. An organization has class C network and forms 48 departments. The subnet mask would be:
(Assuming Classfull addressing scheme is followed.)
(a) 255.255.48.0 (b) 255.255.255.0
(c) 255.255.255.252 (d) 255.255.255.224

16. Class B network on the internet as a subnet mask of 255.255.119.0 what is maximum possible hosts per subnet.
(Assuming Classfull addressing scheme is followed.)
(a) 510 (b) 1022
(c) 1024 (d) 2046

17. Match the following

Group A	Group B
1. IPV4 Address	P. 48 bits
2. MAC Address	Q. 16 bits
3. Port Number	R. 32. bits
4. IPV6 Address	S. 128 bits

(a) 1–P, 2–R, 3–Q, 4–S
(b) 1–R, 2–P, 3–S, 4–Q
(c) 1–R, 2–S, 3–P, 4–Q
(d) 1–R, 2–P, 3–Q, 4–S

18. The subnet mask for the particular network is 255.255.255.31. Which of the following pairs of IP address could belong to this network.
(Assuming Classfull addressing scheme is followed.)
(a) 128.57.62 and 128.56.87.233
(b) 10.35.28.2 and 10.35.29.4
(c) 172.203.31.87 and 172.234.31.88
(d) 192.8.129.32 and 192.8.129.63

19. When we have two networks with 194.194.0 and 194.194.1, what would be the mask to enable communication flow between these networks?
(Assuming Classfull addressing scheme is followed.)
(a) 255.255.255.128
(b) 255.255.254.0
(c) 255.255.0.0
(d) 255.255.255.192

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20. What is the default subnet mask for a class B addressing system?
(Assuming Classfull addressing scheme is followed.)
(a) 255.255.0.0 (b) 255.255.255.0
(c) 255.0.0.0 (d) 0.0.0.0

21. The TTL field in the IP header can be used for:
(a) Trace route
(b) To avoid looping of packet infinitely
(c) To know how many routers are available between source and destination
(d) All of the above

22. If subnet mask of a class C address is 255.255.255.254, then how many subnets and how many systems per subnet are possible?
(Assuming Classfull addressing scheme is followed.)
(a) 64, 2 (b) 1, 254
(c) 0, 0 (d) 128, 0

23. An organization wants to use the network number 192.168.90.0 across four subnets. The maximum number of hosts that exist per subnet will be 25. Which subnet mask would you use to solve this problem?
(Assuming Classfull addressing scheme is followed.)
(a) 255.255.192.7
(b) 255.255.255.66
(c) 255.255.255.15
(d) 255.255.255.23

24. What are the IP addresses used or spanned by the CIDR address 192.168.10.0/20?
(a) 192.168.10.0 through 192.184.15.0
(b) 192.168.0.0 through 208.168.10.0
(c) 192.168.10.0 through 192.184.10.0
(d) 192.168.10.0 through 192.168.150.0

25. Consider the following fields in IP header and choose correct combination:

P: MF	1. Zero for first fragment
Q: DF	2. It must be available in all fragments
R: Offset	3. If it is '1', then fragmentation is not allowed
S: Strict source routing	4. zero for last fragment

(a) P-3, Q-1, R-4, S-2
(b) P-2, Q-3, R-1, S-4
(c) P-4, Q-3, R-1, S-2
(d) P-4, Q-3, R-2, S-1

26. Match the following with correct combination:

P. Time out for ACK as per Jacobson's algorithm in TCP is	1) 0 . 0 . 0 . 0
Q. Default Subnet mask for class B address	2) 0 . 0 . 0 .100
R. Valid source address	3) 255.255.0.0
S. Subnet mask for default Route	4) 255.0.0.0
	5) 2 * D_E + ERTT
	6) 2 * ERTT

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(a) P-5, Q-3, R-2, S-4
(b) P-6, Q-3, R-2, S-1
(c) P-6, Q-3, R-2, S-4
(d) P-5, Q-3, R-2, S-1

27. The CIDR IP address is given as 190.168.0.0 /14 yields approximately how many possible host addresses?
(a) 1024 (b) 2,62,140
(c) 256 (d) 5,12,00

28. Consider 4 networks
199.202.0.0, 199.202.1.0, 199.202.2.0, 199.202.3.0 and perform CIDR aggregation to select one of the following supernet mask.
(a) 255.255.252.0
(b) 255.255.255.252
(c) 255.255.252.255
(d) None of these

29. What is the maximum bandwidth at which an IP host can send 700 bytes of packets without having the 16 bit Datagram identification field wrap around within 100 seconds?
(a) 3.67 Mbps (b) 4.84 Mbps
(c) 1.63 Mbps (d) 2.8 Mbps

30. Consider a network 200.200.1 has 4 subnets and first two bits are borrowed from host ID for subnets. Find the range of IP addresses in subnet with subnet ID 128?
(Assuming Classfull addressing scheme is followed.)
(a) 200.200.1.129 to 190
(b) 200.200.1.128 to 190
(c) 200.200.1.129 to 192
(d) 200.200.1.129 to 190

31. How many number of hosts and usable hosts a network can have with /21 notation.
(a) 1024, 1022
(b) 1022, 1024
(c) 2046, 2048
(d) 2048, 2046

32. Using the IP address 172.168.42.58 and subnet mask 255.255.252.0, identify the correct subnet ID and directed broadcast address.
(Assuming Classfull addressing scheme is followed.)
(a) The correct Network ID is 172. 168.40.0, and the broadcast address is 172.168.255.255
(b) The correct Network ID is 172. 168.40.0, and the broadcast address is 172. 168.43.255
(c) The correct Network ID is 172. 168.40.0, and the broadcast address is 172.168.44.255
(d) The correct Network ID is 172. 168.40.0, and the broadcast address is 172. 169.43.255

33. What is the range of IP address and directed broadcast address for the subnet 219.7.9.72
(Assuming Classfull addressing scheme is followed.)
(a) 219.7.9.72- 219.7.9.78, 219.7.9.79
(b) 219.7.9.73- 219.7.9.78, 219.7.9.79
(c) 219.7.9.73- 219.7.9.78, 219.7.9.255
(d) 219.7.9.73- 219.7.9.78, 219.7.9.248

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34. Assume that the IP address is 108.77.51.70 and subnet mask is 255.255.128.0.
What is the subnet number and host number? (Assuming Classfull addressing scheme is followed.)
(a) 108.77.0.0, 0.0.51.70
(b) 0.0.51.70, 108.77.0.0
(c) 0.77.0.0, 0.0.51.70
(d) 0.0.51.70, 0.77.0.0

35. An ISP is working with a new company to allocate it a portion of address space based on CIDR. The new company needs IP address for machines in three divisions of its corporate network. Engineering, marketing and sales.
These divisions plan to grow as follows.
Engineering: initially fine and adds one system for every week.
Marketing: marketing will never used more than 16 systems.
Sales: every year adds 28 systems what address range would be required to support the company's grown plans for next five years?
(a) 9 bits /24 address (b) 9 bits/23 address
(c) 9 bits/16 address (d) 30 addresses

36. Why do you think IP4 has fragment reassembly done at the end point, rather than at the next hop router?
(a) Fragment may follow the same route
(b) Fragments may follow the different routes
(c) Different networks will have the same MTU size
(d) Intermediate routers do not know the reassemble algorithm.

37. An organization has network growth plans as follows:
Network A: Starts with 20 systems and may go maximum up to 100.
Network B: 150 systems.
Network C: Every month 20 systems will be added.
Propose an appropriate supernet mask for the organization network to handle the situation for next 3 years.
(Assuming Classfull addressing scheme is followed.)
(a) 255.255.255.0 (b) 255.255.0.0
(c) 255.255.252.0 (d) 255.255.0.252

38. Using the IP address 12.14.14.22/22, identify which of the following statements are true. Choose the appropriate answer.
(a) This address and mask will yield a total of 1022 usable hosts per network, with 16,384 usable sub networks.
(b) This is a Class A address with 22 bits masked for subneting, which will yield 8 host bits for a total of 1024 hosts per network, with 64 total sub networks.
(c) This is a Class A address that is using 14 bits for subneting, and leaving 8 host bits.
(d) There are 22 bits masked with this Class B IP address, offering us 8 host bits for a total of 1020 hosts per network, with 64 total sub networks.

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Data for Q39 to Q40 are given below. Solve the problems and choose correct answer

Subnet mask of the network is 255.255.255.240. Suppose a datagram with 192.55.12.120 as D.IP arrived at the network.

(Assuming Classfull addressing scheme is followed.)

39. What is the Subnet ID the host belongs to?
    (a) 112 (b) 8
    (c) 8 (d) 40

40. What is the Host ID?
    (a) 112 (b) 8
    (c) 80 (d) 40

41. The value carried by the fragment offset field in IP header is 100, then how many bytes are ahead of this fragment
    (a) 100 bytes (b) 400 bytes
    (c) 800 bytes (d) 0 bytes

42. If an ICMP packet is encapsulated in IP Packet and in turn encapsulated in the Ethernet frame, then, what is the minimum and maximum frame size?
    (a) Min 576 bytes; max 65536 bytes
    (b) Min 532 byes; max 65496 bytes
    (c) Min 255 bytes; max 2048 bytes
    (d) Min 64 bytes; max 1518 bytes

43. Which of the following field values will not vary under any circumstances in IP header when packet is moving from one router to another router?
    (a) SIP (b) TTL
    (c) Header checksum (d) 13 bit offset

44. If IP fragment offset for a fragment is equal to 40, then the number of datagram bytes ahead of this fragment is _____ bytes

45. In IP fragmentation, more fragment bit=1, fragment offset = 30 and it has to go through a network with maximum transport unit (MTU) is 100 bytes, how many further fragments are possible?
    (a) 3 (b) 2
    (c) 1 (d) Insufficient data

46. An IP router with MTU of 1200 bytes has received an IP packet of size 4408 bytes with an IP header of 20 bytes. The values of the MF and offset of the 4th IP fragment is
    (a) MF: 1, offset = 404
    (b) MF: 1, offset = 294
    (c) MF: 0, offset = 404
    (d) MF: 0, offset = 494

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Solutions

01. Ans: (b)

Sol: Class B Address has 16 Net ID, 16 Host ID

255.255.11110000.00000000

4 bits are assigned for subnet ID

12 bits for host ID

Number of Hosts = $2^{12} - 2$

$= 4096 - 2 = 4094$

02. Ans: (a)

Sol: Class C → 24 bits NID

8 bits HID

A has 72 bits → 7 Bits for HID

A → 255.255.255.128

B has 35 Hosts → 6 bits

B → 255.255.255.192

C → 20 Hosts } 5 bits

D → 18 hosts

C & D → 255.255.255.223

03. Ans: (a)

Sol: 108.77.51.70 → class A address

8 bit NID

24 bit HID

255.11111111.10000000.00000000

7 bits – subnet ID. 17 bit host

Subnet number = IP AND subnet mask

= 108.77.0.0

Host number = IP AND subnet mask

= 0.0.51.70

04. Ans: (c)

05. Ans: (c)

Sol: Private address →

10.0.0.0 to 10.255.255.255 – class A

172.16.0.0 to 172.31.255.25 – class B

192.168.0.0 to 192.168.255.255 – class C

10.1.1.1 → Class A private host address

06. Ans: (a)

Sol: 127.1.1.1 → Special address (loop back)

255.255.255.255 → Limited broadcasting

10.0.0.0 → Private address (this network address)

0.0.0.100 → Source IP/Destination IP

07. Ans: (b)

Sol: Both are class C addresses 205.100.0.0/22 has 4 networks (24–22) = 2 bits.

It begins from 205.100.0.0

205.100.0.0/20 has 16 networks (24–20 = 4)

$= 2^4$

It begins from 205.100.0.0

It chooses an address with long prefix 205.100.0.0/20

08. Ans: (c)

Sol: class C has → 24 bits – NID

8 bits – HID

4 subnets require 2 bits – SID

6 bits – HID

255. 255. 255. 11000000

255. 255. 255. 192

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09. Ans: (d)

Sol: Class B address

35 → departments

6 bit subnet id ($2^6 = 64$ subnets)

10 bit Host id ($2^{10} - 2 = 1022$ Host)

10. Ans: (b)

11. Ans: (a)

Sol: $2^{10} - 2$ hosts as we have 10 zeros in SM.

Maximum possible hosts per subnet $= 2^{10} - 2$

$= 1022$

12. Ans: (b)

Sol: Since it /19, remaining 13 bits (out of 32 bits of IP4) will be used for HID.

13. Ans: (d)

Sol: For 200 subnets we need to borrow 8 bits from HID, rest of the 8 bits are allocated to hosts. In 255.255.0.0 we borrowed all 16 bits for SID and zero bits left over for HID which is not correct.

14. Ans: (b)

Sol: 173.250.10.1 → 173 → 10101101

→ class B address

NID – 16 bits, HID – 16 bits

15. Ans: (c)

Sol: It borrows 6 bits from HID. It is class C (255.255.255.252).

16. Ans: (b)

Sol: Class B network has 16 bits HID

255.255.01110111.0

6 bits SID

HID = 10 bits

17. Ans: (d)

18. Ans: (d)

Sol: Option (d) is class C address and belongs to same network.

19. Ans: (b)

Sol: Supernet must be created to combine both of them, for that we need one bit from network ID.

20. Ans: (a)

Sol: Class B address has 16 bit Net ID and 16 bit Host ID

The default subnet mask is 255.255.0.0

21. Ans: (d)

Sol: TTL avoid infinite looping, it contains number of hops between source and destination

22. Ans: (d)

Sol: Class C address has 3 bytes net ID and 1 byte host ID 255.255.255.11111110

7 bits for subnet $\Rightarrow 2^7$ subnets

1 bit for host $\Rightarrow 2^1 - 2 = 0$ host

23. Ans: (b)

Sol: IP address is class C, 24 bits Net ID, 8 bit Host ID

Each subnet has 25 hosts

4 subnets ⇒ 2 bits

255.255.255.66

255.255.255.01000010

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24. Ans: (d)

Sol: Class C address

CIDR address 192.168.10.0/20

20 bits fixed part

12 bits variable part

$24 - 20 = 4$

$2^4 = 16$

192.168.10.0 through 192.168.150.0

25. Ans: (c)

Sol: MF → last fragment zero

DF → Do not fragment is 1, then no more fragments

offset → First fragment offset is always zero

strict source Routing → must be available in all the fragment

26. Ans: (d)

Sol: P: Timeout = $2 \times D_E$ + ERTT

Where D_E → Estimated Deviation,

ERTT = Estimated RTT

Q: class B has 16 bit NID, 16 bit HID

255.255.0.0

R: 0.0.0.100 because

S: 0.0.0.0

27. Ans: (b)

Sol: 14 – 1's in the subnet mask.

∴ 18 bits Host ID

28. Ans: (d)

Sol: Class – C Address

24 bits – NID

8 bits – HID

Choose a supernet such that it must have less number of 1's than NID

29. Ans: (a)

Sol: Wraparound time = 100 sec

$$\text{wraparound time} = \frac{\text{Total number of bits}}{\text{Bandwidth}}$$

$$100\text{sec} = \frac{2^{16} \times 700 \times 8}{\text{Bandwidth}}$$

$$\text{Bandwidth} = \frac{2^{16} \times 700 \times 8}{100}$$

$$= 3.67\text{Mbps}$$

30. Ans: (a)

Sol: Class C address

↓

24 bits – NID

8 bits – HID

2 bits are borrowed for SID

∴ ($2^2 = 4$ subnets)

∴ 6 bits for host ID (2^6–2)=62 Hosts/subnets

200.200.1.129 to 190

200.200.1.10000000 → host begins from 1 onwards

31. Ans: (d)

Sol: 21 notation has 21one's and 11 zero's

21 is fixed part

11 is variable part

Total possible hosts are $2^{11} = 2048$

Usable hosts are $2^{11} - 2 = 2046$

32. Ans: (b)

Sol: 172.168.42.58 Class B address

Directed Broadcast ID = IP OR 7 Subnet Mask

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172.168.00101010.00111010
0 .0 .00000011.11111111
172.168.00101011.11111111
172.168.43.255

Subnet ID: IP AND Subnet 172.168.40.0

33. Ans: (b)

Sol: Host number: IP AND subnet mask.
: 219.7.9.72 AND 255.255.255.248
: 219.7.9.72
Range of IP address:

219.7.9.73 – 219.7.9.78
6 Hosts

Directed broadcast address: Turn on host bits

219.7.9.01001111
219.7.9.79 → Host bits

34. Ans: (d)

Sol: Subnet number: IP AND 7 subnet Mask

→ 108.77. 00110011. 01000110
0 . 0 . 01111111. 11111111
0 . 0 . 00110011. 01000110
0 . 0 . 51.70

Host number: IP OR 7 subnet Mask
0.77.0.0

35. Ans: (b)

Sol: **Engineering:** initially 5 addresses add one system for every week per one year it requires 52 extra addresses per 5 years it requires 52 × 5 = 260 extra addresses, total 265 addresses → 9 bits.

Marketing : Max 16 systems → 4 bits
Sales : 28 + 5 (one per year)
= 33 → 6 bits

Max number of bits required
9 bits / 23 address

36. Ans: (b)

Sol: Fragments will not follow same route.

37. Ans: (c)

Sol: Network A: 20 – max 100 = 7 bits
Network B: 150 – 8 bits
Network C: 20 per month
3 years – 36 months – 720
addresses – 10 bits
32 – 10 = 22 bits per supernet
11111111.11111111.11111100.00000000
255.255.252.0

38. Ans: (a)

Sol: 12.14.14.22/22 → 22 one's, 10 zero's
Number of hosts = $2^{10} - 2 = 1022$
It is class A address – 24 bits HID,8 bit NID
14 bits borrowed from HID
$2^{14} = 16384$ Subnets

39. Ans: (a)

Sol: Subnet mask
255.255.255.240
255.255.255.11110000
Dest. IP : 192.55.12.120
Subnet host & DIP are same

192. 55 .12 .01111000
AND
255.255.255.11110000
192. 55 .12 .01110000
= 192.55.12.112

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40. Ans: (b)

Sol: Host ID part after network: 8 (1000)

41. Ans: (c)

Sol: offset = 100

8 * 100 = 800 bytes

42. Ans: (d)

Sol: Data size in Frame

Min	Max
46	1500
72	1526 → frame
64	1518 →frame from source address

43. Ans: (a)

Sol: Intermediate routers just use SIP for feedback messages, if needed, but never change it.

44. Ans: 320

Sol: Fragment offset = datagram data/8, so it is 320 bytes.

45. Ans: (d)

Sol: It is not possible to find further fragments without knowing number of datagram bytes in fragment.

46. Ans: (c)

Sol: Data + header must be less than or equal to MTU

	MF	Length	Offset
Fragmetn1:	1	1176	0
Fragment2:	1	1176	147
Fragment3:	1	1176	294
Fragment4:	0	870	404

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Chapter 5 Routing Algorithms

01. Suppose a router has built up the routing table shown below:

Subnet number	Subnet mask	Next hop
128.96.39.0	255.255.255.128	Interface 0
128.96.39.128	255.255.255.128	Interface 1
128.96.40.0	255.255.255.128	R_2
192.4.153.0	255.255.255.192	R_3
0.0.0.0	0.0.0.0	R_4

Match what the router does with a packet addressed to each of the following destinations.

P : 128.96.39.10	1) R_2
Q : 128.96.40.12	2) R_3
R : 128.96.40.151	3) Default
S : 192.4.153.17	4) Interface 0
	5) Interface 1

(a) P-4, Q-1, R-3, S-2
(b) P-2, Q-5, R-1, S-3
(c) P-2, Q-5, R-1, S-4
(d) P-4, Q-1, R-5, S-2

02. **Assertion (A):** Distance Vector Routing typically provides information for topology changes by using periodic table updates while Link State Routing updates are commonly triggered by topology changes.

Reason (R): Distance Vector Routing has a quick convergence while Link State Routing has a slow convergence.

03. Suppose we have the following forwarding tables:

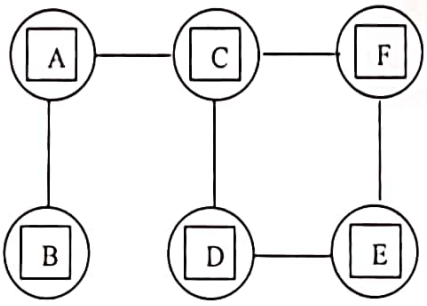
NODE A Forwarding table:

Node	Cost	Next Hop
B	1	B
C	1	C
D	2	B
E	3	C
F	2	C

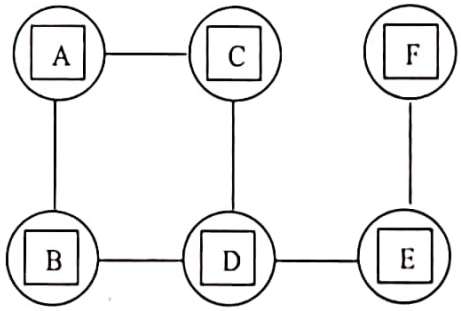
Node	Cost	Next Hop
A	2	C
B	3	C
C	1	C
D	2	C
E	1	E

All links have cost 1. Choose a diagram of the smallest network consistent with these tables:

(A)



(B)



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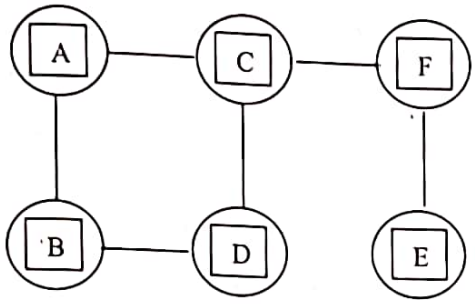
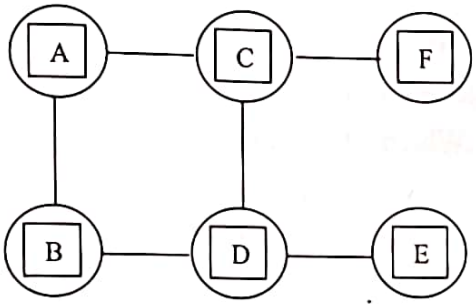
(C)



(D)



(a) Figure A (b) Figure B
(c) Figure C (d) Figure D

Common Data for Questions 04 & 05

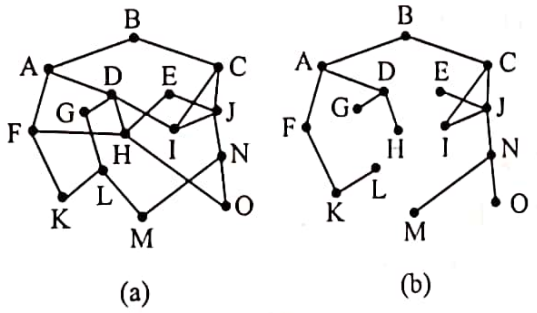


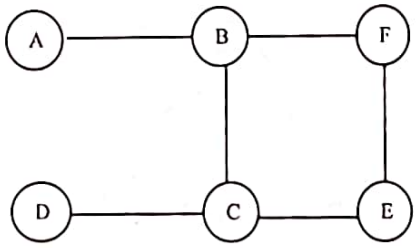
Fig: (a) A subnet. (b) A sink tree for router B.

04. Looking at the above subnet, find how many hops and how many packets are generated by a broadcast from B using the sink tree ?
(a) 5 hops, 15 packets
(b) 4 hops, 14 packets
(c) 5 hops, 24 packets
(d) 4 hops, 24 packets

05. Looking at the above subnet, find how many hops and how many packets are generated by a broadcast from B using the reverse path forwarding?
(a) 5 hops, 15 packets
(b) 4 hops, 14 packets
(c) 5 hops, 21 packets
(d) 4 hops, 21 packets

Common Data for Questions 06 & 07

Consider the following subnet and Distance vector routing is used.



06. The following vectors have just come in to router C:
From B : (5, 0, 8, 12, 6, 2);
From D: (16, 12, 6, 0, 9, 10);
From E: (7, 6, 3, 9, 0, 4)

The measured delays to B, D and E are 6,3,5. What is the C's new routing table?

(a) <A-12, B-11, C-0, D-12, E-9, F-5>
(b) <A-21, B-1, C-0, D-1, E-9, F-5>
(c) <A-11, B-6, C-0, D-3.E-5, F-8>
(d) <B-11, B-6, C-0, D-3, E-5, B-8>

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07. The following vectors have just come in to router A:

From B : (8, 0, 8, 12, 6, 2);

From D: (6, 12, 5, 0, 9, 10)

The measured delays to B and D are 3 and 5. What is the A's new routing table

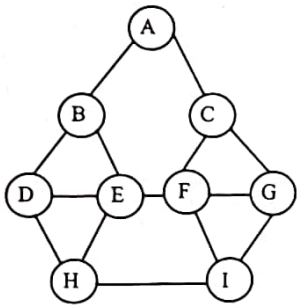
(a) <A-0, B-11, C-5, D-12, E-9, F-5>

(b) <A-0, B-1, C-8, D-1, E-9, F-5>

(c) <A-0, B-3, C-10, D-5, E-9, F-5>

(d) <A-0, B-2, D-5, D-1, E-9, F-5>

Statement for Linked answer Q08 and Q09 is given below.



08. Looking at the above subnet, calculate how many packets are generated by a broadcast from router 'A', using sink tree method

(a) 7 (b) 8

(c) 9 (d) 10

09. Upon generated sink tree of the above question, now consider the reverse path forwarding and calculate the number of hops to broadcast a packet from router 'A'?

(a) 4 (b) 5

(c) 6 (d) 7

10. Consider the following subnet:

Distance vector routing is used and the following vectors have just come in to router C.

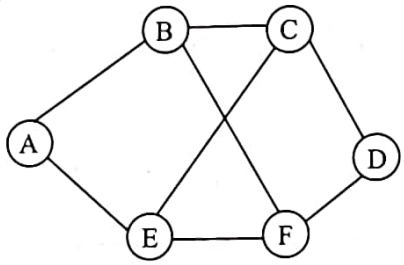
From B: (3, 0, 3, 5, 10, 5)

From D: (10, 11, 3, 0, 12, 6) and

From E:(5, 6, 7, 3, 0, 7).

The measured delays to B,D and E are 8,6 and 5 respectively.

Which of the following is the C's new table (only Distance vector):



(a) (10, 11, 0, 5, 10, 11)

(b) (10, 11, 0, 6, 5, 12)

(c) (10, 11, 3, 0, 12, 6)

(d) (10, 8, 0, 6, 5, 10)

11. Pick up the ***correct*** statement:

P: Multipath routing algorithm is a NonAdaptive

Q: RCC prepares RITs in Isolated Routing algorithms.

R: OSPF is based on Distance Vector Algorithm

S: In Flooding, all packets received by destination must have followed the best path

(a) P (b) Q

(c) R (d) S

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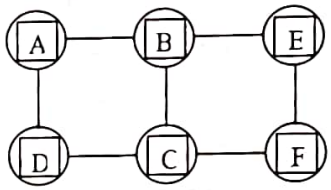
12. In which routing method do all the routers have a common database?
(a) Distance Vector Routing
(b) Link State Routing
(c) Link Vector Routing
(d) None of the above

Common Data Question for 13 & 14

In the given figure, routers A, B, C and D use split horizon with poisonous reverse. The initial status of their vectors is as shown.

Information Stored at node	Distance to reach node					
	A	B	C	D	E	F
A	0	2	∝	5	∝	∝
B	2	0	2	∝	1	∝
C	∝	2	0	2	∝	3
D	5	∝	2	0	∝	∝
E	∝	1	∝	∝	0	3
F	∝	∝	3	∝	3	0



13. What are the revised distance vectors of router C after they received the distance vector from B?
(a) C: <A-2, B-1, D-2>
(b) C: <A-2, B-1, D-1>
(c) C: <A-1, B-1, D-2>
(d) C: <A-1, B-2, D-1>

14. What are the revised distance vectors of routers D after they received the distance vector from B?
(a) D: <A-1, B-1, C-2>
(b) D: <A-2, B-1, C-2>
(c) D: <A-2, B-1, C-1>
(d) D: <A-1, B-2, C-1>

Statement for Linked answer Q15 and Q16 is given below.

The following table depicts the global distance vector table where each node knows only the distance to its immediate neighbours.

Considering the following table options to answer the questions for 15 & 16.

Table: One

Information Stored at node	Distance to reach node					
	A	B	C	D	E	F
A	0	2	4	5	3	6
B	2	0	2	4	1	4
C	4	2	0	2	3	3
D	5	4	2	0	5	5
E	3	1	3	5	0	3
F	6	4	3	5	3	0

Table: Two

Information Stored at node	Distance to reach node					
	A	B	C	D	E	F
A	0	2	4	5	3	∝
B	2	0	2	4	1	4
C	∝	2	0	2	2	3
D	5	∝	2	0	2	A
E	∝	1	∝	∝	0	3
F	4	4	3	∝	3	0

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Table: Three

Information Stored at node	Distance to reach node					
	A	B	C	D	E	F
A	0	2	4	5	3	∝
B	2	0	2	4	1	4
C	∝	2	0	2	3	3
D	∝	4	∝	0	5	5
E	3	1	3	5	0	3
F	6	4	3	5	∝	0

Table: Four

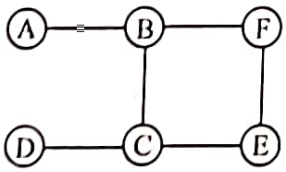
Information Stored at node	Distance to reach node					
	A	B	C	D	E	F
A	0	2	4	5	3	∝
B	2	0	2	4	1	4
C	4	2	0	2	3	3
D	5	4	2	0	∝	5
E	3	1	3	∝	0	3
F	∝	4	3	5	3	0

15. Distance Vector algorithm is implemented and each node has reported the information it had in the preceding step to its immediate neighbours, then what is the global distance-vector table?

(a) Table: One (b) Table: Two

(c) Table: Three (d) Table: Four

16.



Consider the subnet and Distance vector routing is used.

The following vectors have just come in to router C: from B: (5, 0, 8, 12, 6, 2) from D: (16, 12, 6, 0, 9, 10) from E: (7, 6, 3, 9, 0, 4). The measured delays to B, D and E are 6, 3, 5. What is the C's new routing table?

(a) <A–12, B–11, C–0, D–12, E–9, F–5>

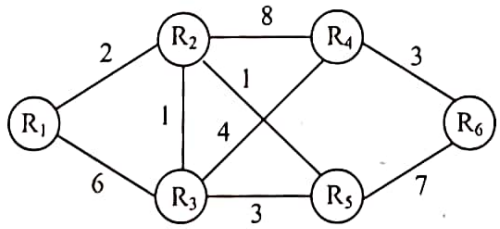
(b) <A–11, B–6, C–0, D–3, E–5, F–8>

(c) <A–21, B–1, C–0, D–1, E–9, F–5>

(d) None of these

Statement for Linked Questions 17 & 18:

Consider a network with 6 routers R_1 to R_6 connected with links having weights as shown in the following diagram



17. All routers use the distance vector based routing algorithm to update their routing tables. The shortest distance between R_1 and R_6.

(a) 13 (b) 10 (c) 12 (d) 17

18. What is the initial routing table of router R_4

(a)

R_1	10
R_2	8
R_3	4
R_4	0
R_5	∞
R_6	3

(b)

R_1	∞
R_2	8
R_3	4
R_4	0
R_5	7
R_6	3

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(c)

R_1	10
R_2	8
R_3	4
R_4	10
R_5	7
R_6	3

(d)

R_1	∞
R_2	8
R_3	4
R_4	0
R_5	∞
R_6	3

19. Assume that for OSPF updates occur every 30 minutes, an update can carry three LSAs and each LSA is 36 bytes long, overall OSPF common header is 28 bytes. Estimate the bandwidth required in advertising LSA.

(a) 0.201 bits/sec (b) 0.604 bits/sec
(c) 0.121 bits/sec (d) 0.873 bits/sec

20. OSPF send hello messages to know about neighbors for every 10 seconds. Number of links in the network is 'L'. Hello packet header size is 20 bytes. The degree of router (number of links connected) is 'm'. Each router ID consumes 4 bytes. Estimate the size of the hello messages.

(a) 20 + m bytes (b) 20 + 4m bytes
(c) 4m bytes (d) 20 bytes

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Solutions

01. Ans: (a)

Sol: **P:** 128.96.39.10 AND 255.255.255.128

128.96.39.00001010
255.255.255.10000000
128.96.39.00000000
0 → next hop = Interface=0

Q:

128.96.40.00001100
255.255.255.10000000
128.96.40.0 → next hop = R_2

R:

128.96.40.10010111
255.255.255.10000000
128.96.40.128 → default

S:

192.4.153.00010001
255.255.255.10000000
192.4.153.00000000
0 → R_3

02. Ans: (d)

Sol: A is true but R is false.

03. Ans: (c)

Sol: All links have cost 1.

From A

A → B via B 1

A → C via C 1

A → D → via B/C 2

A → E → via C → F 3

A → F → via C

From F

F → A via C 2

F → B via C 3

F → C via C 1

F → D via C 2

F → E via E 1

04. Ans: (b)

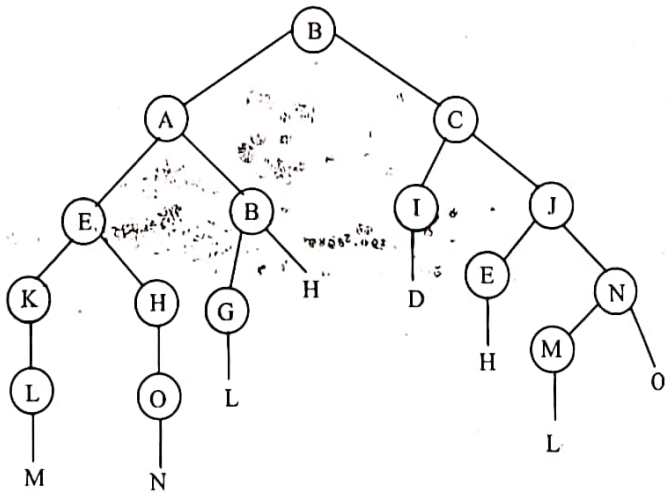
Sol: Maximum hop distance B is 4 hops. There are 14 nodes excluding B. Totally generated packets are 14.

05. Ans: (c)

Sol: The built tree by reverse path forwarding

5 hops

21 packets



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06. Ans: (c)

Sol:

C's updated Routing table

A	C →B→A, C→D→A, C→E→C (11, 19, 12) 11
B	C→B(6), C→D→B(15), C→E→B(11) 6
C	0
D	C→D(3) 3
E	C→E(5) 5
F	C→B→F(8), C→D→F(13), C→E→F(19) 8

07. Ans: (c)

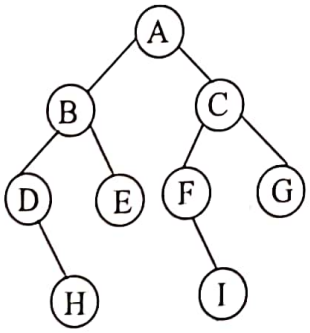
Sol:

A's new routing table

A	0
B	A→B(3), A→D→B(5+12) 3
C	A→B→C(3+8), A→D→C(5+5) 10
D	A→D(5), A→B→D(3+12) 5
E	A→B→E(3+6), A→D→E(5+9) 9
F	A→B→F(3+2), A→D→F(5+10) 5

08. Ans: (b)

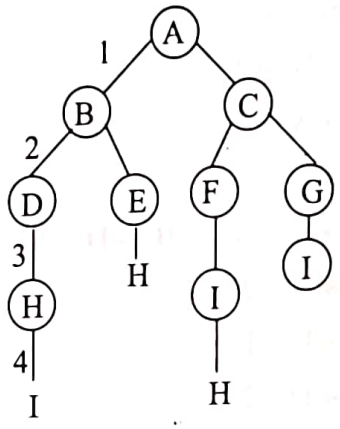
Sol: Sink tree



8 Packets are generated

09. Ans: (a)

Sol: Reverse Path Forwarding



4 hops

10. Ans: (d)

Sol:

C's new table	
A	C→B→A(8+3), C→D→A (6+10), C→E→A(5+5) 10
B	C→B (8), C→D→B (6 +11), C→E→B (5+6) 8
C	0
D	6
E	5
F	C→B→F (8+5), C→D→F (6+6), C→E→F (5+7) 12

11. Ans: (c)

Sol: Every packet must have short virtual circuit number

All packets follow the same path

It is connection – oriented service.

Not required source and destination address but use VC number.

12. Ans: (b)

Sol: Link state routing maintains a common database for all the nodes.

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13. Ans: (a)

Sol: C router update – after receiving distance from B is

$C \to B \to 1$

$B \to A$ is 1

$C \to A$ is 2

$C \to D \Rightarrow C \to B \to D = 2$

$C \to A = 2$

$C \to B = 1$

$C \to D = 2$

14. Ans: (b)

Sol: $D \to A \Rightarrow D \to B \to A = 2$

$D \to B \Rightarrow 1$

$D \to C \Rightarrow D \to B \to C = 2$

15. Ans: (d)

Sol: Using immediate neighbor Routing table

Information Stored at node	Distance to reach node					
	A	B	C	D	E	F
A	0	2	4	5	3	α
B	2	0	2	4	1	4
C	4	2	0	2	3	3
D	5	4	2	0	α	5
E	3	1	3	α	0	3
F	α	4	3	5	3	0

$A \to F$: Not neighbor to either B or D

$E \to D$: is not neighbor to either B or F

$F \to A$: A is not neighbor to either C or E

16. Ans: (b)

17. Ans: (b)

Sol: It has two shortest paths

$R_1 \to R_2 \to R_3 \to R_4 \to R_6$

$R_1 \to R_2 \to R_5 \to R_6$

18. Ans: (d)

19. Ans: (b)

Sol: LSA size = 36 bytes

Header size = 28 bytes

Overall LSA message = $28 + 3 \times 36$

= 136 bytes

$$\text{Bandwidth} = \frac{\text{Total LSA size}}{\text{time}}$$

$$= \frac{136 \times 8}{30 \times 60} \text{ bits/sec}$$

= 0.604 bits/sec

20. Ans: (b)

Sol: Hello packet header = 20 bytes

No. of links connected = m

Router ID consumes 4 bytes

Size of hello message = hello packet header + no. of links * router ID

= 20 + 4m bytes

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Chapter 6 TCP/UDP & Sockets, Congestion Control

01. In TCP header, we have "Receiver window size" field, it is used to know about the amount of the space available at the receiver, and its value is equal to
(a) Receiver window = Receiver window – (last byte received – last byte read)
(b) Receiver window = Receiver window + (last byte received – last byte read)
(c) Receiver window = Receiver buffer – (last byte received – last byte read)
(d) Receiver window = Receiver buffer + (last byte received – last byte read)

02. In TCP, the timeout value is equal to
(a) Estimated RTT + 4 × deviation
(b) Estimated RTT – 4 × deviation
(c) Estimated RTT × 4 × deviation
(d) 4 + deviation × estimated RTT

03. In TCP congestion control, the congestion window
(a) Increases exponentially
(b) Increases exponentially up to threshold value after that increases linearly
(c) Increases exponentially up to threshold value after that increases linearly up to the sender's window size
(d) None of the above

04. If the TCP, RTT, is currently 30 msec, and the ACK comes in 26 msec, and $\alpha = 0.9$ then what is the new RTT value
(a) 29.0 (b) 28.6
(c) 29.84 (d) 29.6

05. Suppose that the TCP congestion window is set to 18 KB and at time out occurs. How big will the window be if the next five transmission bursts are all successful?
(a) 8 KB (b)16 KB
(c) 32 KB (d) 18 KB

06. Which flag is used to take care of "out of band" data, in TCP header
(a) RST (b) SYN
(c) FIN (d) URG

07. What are the protocol parameters that might be negotiated when a connection is set up?
(a) Window size, maximum packet size and total data size.
(b) MSS, timer values and total data size
(c) Window size, maximum packet size and total number of packets
(d) MSS, timer values, Window size

08. Suppose a packet arrives at a router and is to be forwarded to an X.25 network having MTU of 576 bytes. The packet has an IP header of 20 bytes and data part of 1484 bytes. If we perform fragmentation then what is the fragment offset value for the last fragment.
(a) 0 (b) 69
(c) 138 (d) 1104

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09. TCP operates over a 40 Gbps link. If TCP uses the full bandwidth continuously, how long would it take the sequence numbers to wraparound completely.
(a) 962 ms (b) 330 ms
(c) 859 m (d) 642 ms

10. Assume that TCP implements an extension that allows window size much larger than 64 kB. Suppose that you are using this extended TCP over a 1-Gbps link with a latency of 100ms to transfer a 10 MB file and the TCP receive window is 1 MB. If TCP sends 1-kB packets.(assuming no congestion and no last packets). How many RTTs does it take until slow start opens the send window to 1MB.
(a) 15 RTTs (b) 20 RTTs
(c) 5 RTTs (d) 10 RTTs

11. What are the following different parameters needed to identify the TCP connections between client and servers in internet or WAN or LAN.
1. S.port 2. D.port
3. S.IP 4. D.IP
(a) 1, 2 (b) 3, 4
(c) 1, 2, 3 (d) 1, 2, 3, 4

12. What are the reasons for "Silly Window Syndrome"?
(i) Receiver announces advertised window as zero
(ii) Client generates only one byte at a time
(iii) Router processes only one byte data at a time.
(iv) Server consumes only one byte at a time.
(a) [i],[ii],[iii] are the reasons
(b) [i],[ii] are the reasons
(c) [i],[ii],[iv] are the reasons
(d) [i],[ii],[iii],[iv] are the reasons

13. Byte count variation of leaky bucket algorithm is used in a switch at the output interface to regulate the traffic to send 8000 bytes per tick. If the following frames are received in sequence, then in how many ticks, all the frames are transmitted.
Frames 1,2,3,4 : 4000 bytes each
Frames 5, 6, 7 : 3200 bytes each
Frames 8,9 : 400 bytes each
Frames 10,11,12,13,14,15 : 2000 bytes each
(a) 4 ticks (b) 5 ticks
(c) 6 ticks (d) 7 ticks

14. Imagine a flow specification that has a maximum packet size of 1000 bytes, a token bucket rate of 10 million bytes/sec, a token bucket size of 1 million bytes, a maximum transmission rate of 50 million bytes/sec. How long can a burst at maximum speed last?
(a) 25 msec (b) 125 sec
(c) 20 msec (d) 5 sec

15. A computer uses a token bucket algorithm for traffic shaping. The token bucket is regulated at the rate of 1 Mbps. It is initially filled to a capacity with 6 megabits. How long can the computer transmit at the full 5 Mbps?
(a) 4.5 sec (b) 2.8 sec
(c) 1.5 sec (d) 1.4 sec

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16. Suppose that the TCP entity receives a 1.5 megabyte file from the application layer and that the IP layer is willing to carry blocks of maximum size 1500 bytes. Calculate the amount of overhead incurred from segmenting the file into packet sized units.
(a) 1.8% (b) 2.8%
(c) 3.8% (d) 4.8%

17. TCP client is sending full windows of 65,535 bytes over 1 Gbps channel. If TCP round trip RTT is currently 30 msec and the following acknowledgments come in after 26, 32 and 24 msec respectively. Use $\alpha = 0.9$, $D_i = 5$.
What is the ERTT after third transmission using Jacobson's algorithm?
(a) 29.624 msec (b) 29.256 msec
(c) 29.846 msec (d) 29.166 msec

Common Data for Q18 & Q19 is given below.

Suppose a TCP message that contains 2048 bytes of data and 20 bytes of TCP header is passed to IP for delivery across two networks of the internet. The first network uses 14 byte header and has an MTU of 1024 bytes, the second uses 8 byte header with an MTU of 512 bytes. Each network's MTU gives the size of largest IP datagram that can be carried in a link layer frame. Assume all IP headers are 20 bytes.

18. Find the offset value for the last fragment in first network (i.e., with MTU of 1024 bytes)
(a) 124 (b) 123
(c) 246 (d) 248

19. How many fragments received by destination all together and what is the offset for 5th fragment?
(a) 5, 183 (b) 6, 183
(c) 7, 183 (d) 8, 246

20. Which one of the following field is constant in TCP header for all segments in a message?
(a) Source port
(b) Ack num
(c) Seq num
(d) Advertised window

21. A TCP session sends 10 packets per second over an Ethernet Local Area Network (LAN). Each Ethernet packet has payload of 1466. Therefore what is the TCP throughput of the session?
(a) 100 kbps (b) 112 kbps
(c) 140 kbps (d) 175 kbps

22. TCP uses SWP to control the flow between sender and receiver. TCP advertises its empty space at receiver's side in terms of "AdvertisedWindow", then sender computes "EffectiveWindow" that can be transferred from sender, this is equal to:
(a) Effective Window = AdvertisedWindow (Last Byte Sent + Last Byte Acked)
(b) Effective Window = Advertised Window – (Last Byte Sent – Last Byte Acked)
(c) Effective Window = Advertised Window + (Last Byte Sent – Last Byte Acked)
(d) It cannot be calculated

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23. In 45 Mbps line, how long it takes to wraparound the 32 bit sequence number space.
(a) 14.72 seconds (b) 12.72 minutes
(c) 6.72 hrs (d) 14.72 minutes

24. In a network that has a maximum packet size of 128 bytes, maximum packet life time of 30 seconds and an 8 bit sequence number. What is the maximum data rate per connection?
(a) 5.7 KBPS (b) 10 KBPS
(c) 9.5 KBPS (d) 8.7 KBPS

25. The total length of the Pseudo header used in TCP checksum is
(a) 8 bytes (b) 16 bytes
(c) 12 bytes (d) 20 bytes

26. The average throughput of a TCP connection is:
(a) (W × MSS) / RTT
(b) (2 W × MSS) / RTT
(c) (0.75 × W × MSS) / RTT
(d) (W × MSS) / 2 RTT

27. TCP uses timer to calculate time out for every transmission. Consider the initial deviation for the system is 5, smoothening factor $\alpha = 0.9$ and initial RTT is 30 msec. Calculate estimated RTT, if you get ACK at 40 msec.
(a) 27 msec (b) 31 msec
(c) 30 msec (d) 4 msec

28. What is the maximum bandwidth at which an IP host can send 576 byte packets without having the Identity field wraparound within 60 seconds?
(a) 10 Mbps (b) 7.5 Mbps
(c) 5 Mbps (d) 4.5 Mbps

29. TCP timer management maintains an ACK timer to keep track RTT. Assume IRTT = 30 msec and ACK arrives at 40 msec. If initial deviation is 5 msec and smoothening factor is 0.9 then, what is the time out period for the next transmission?
(a) 53 msec (b) 53 sec
(c) 62 msec (d) 31 msec

30. Which one of the following TCP method associates a socket with a specified local port number and IP address?
(a) bind() (b) listen()
(c) accept() (d) connect()

31. While establishing TCP connection, sender and receiver have decided to have 48 KB as window size. To control congestion, congestion window is set to one MSS =1 KB. At one point of time when TCP is in slow start phase, receiver has received 8 acknowledgments. How many number of packets would be transmitted in next communication? Assume no errors or lost packets in communication?
(a) 8 (b) 16
(c) 24 (d) 18

32. If the TCP round-trip time, RTT, is currently 30 msec and the following acknowledgement come in after 26msec, respectively, what is the new Timeout estimate in basic and Jacobsons algorithm? Use α=0.9. Assume initial deviation as 4.

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(a) 59.2 μ sec, 45.6 μ sec
(b) 45.6 m sec, 59.2 m sec
(c) 45.6 μ sec, 59.2 μ sec
(d) 59.2 m sec, 45.6 m sec

33. Which TCP socket function used by both TCP client and TCP server?
(a) bind( ) (b) connect( )
(c) write( ) (d) listen( )

34. Find number of fragments while packet traverse through a network with below details in incoming packet header and network characteristics. Maximum transport unit(MTU) size as 300 bytes, network header as 20 bytes, TCP header as 20 bytes, don't fragment (DF) bit as 1 and incoming datagram data size as 1000 bytes.
(a) 3 fragments (b) 2 fragments
(c) 4 fragments (d) none of the above

35. While establishing TCP connection both W_s and W_r are established as 48,000 bytes. Maximum segment size (MSS) is 3,000 bytes. At one point if sender receives 4 acknowledgments, the window size in next transmission is _____ bytes.

36. Let the size of the congestion window of TCP connection be 64 KB when a timeout occurs. The round trip time of the connection is 80 msec and maximum segment size used is 4 KB. The time taken by the TCP connection to get back to 64 KB congestion window is
(a) 1100 (b) 880
(c) 440 (d) 600

37. If TCP round trip time is 20 msec and following ACKs come in after 24 and 19 msec. if $\alpha = 0.9$ what is the new RTT?
(a) 20.4 (b) 20.26
(c) 21 (d) 20.1

38. A TCP machine is sending windows of 32767 bytes over 512 Mbps channel. It has 10 msec round trip delays what is line efficiency?
(a) 5.119% (b) 51%
(c) 52% (d) 6.1%

39. Suppose the TCP congestion window is set to 18kB and a time out occurs. What will be the window if the next four transmission bursts are all successful and MSS is 1 KB?
(a) 2 (b) 4
(c) 8 (d) 16

40. In a leaky bucket, what should be the capacity of the bucket if the output rate is 5gal/min, and there is an input burst of 100gal/min for 12 sec and there is no input for 48 sec?
(a) 5 (b) 10
(c) 15 (d) 20

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Solutions

01. Ans: (c)

Sol: Receiving window

= Receiver buffer – (last byte received – last byte read)

02. Ans: (a)

Sol: Basic Algorithm Timeout

= 2 * Estimated RTT

where Estimated RTT

$= \alpha * IRTT + (1-\alpha) NRTT$

IRTT = Initial RTT

NRTT = New RTT

Jacobson's Algorithm:

Timeout = 4 × Deviation + ERTT

03. Ans: (c)

Sol: To congestion control, the congestion window size increased exponentially upto threshold value after that it will be increased linearly upto sender's window size.

04. Ans: (d)

Sol: Current RTT = 30 msec

Ack comes in 26 msec ⇒ NRTT = 26 msec

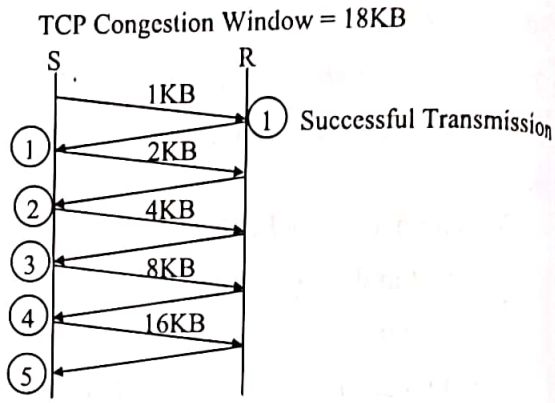
Assume $\alpha = 0.9$

Estimated new RTT = 30 × 0.9 + (1–0.9) 26

= 29.6

05. Ans: (b)

Sol:



The window size = 16 KB after 5 successful transmissions.

06. Ans: (d)

Sol: RST → Reset the connection

SYN → Synchronize sequence number

FIN → No more data from sender

URG → Urgent pointer → is used to check out of band.

07. Ans: (d)

Sol: MSS, timer values, window size

08. Ans: (c)

Sol: MTU = 576 bytes

header = 20 bytes

data = 556 but it is not multiple of 8

552	552	380
+	+	+
20	20	20

offset 0 $\frac{552}{8} = 69$ 138

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09. **Ans: (c)**

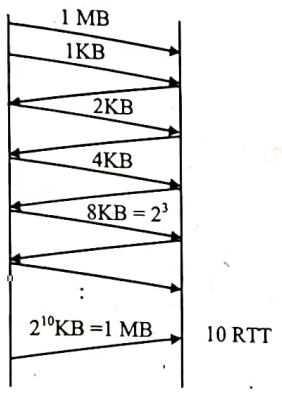
Sol: 1 Sec → 40 GB = 40×10^9 bytes

$$= \frac{40 \times 10^9}{8} \text{ bytes}$$

$$= \frac{1 \times 2^{32}}{40 \times 10^9} \times 8 = 858.99 \text{ m}$$

10. **Ans: (d)**

Sol:



11. **Ans: (d)**

Sol: Socket needs (S.IP, S.Port) and (D.IP, D.Port) Sockets are used in TCP.

12. **Ans: (c)**

Sol: This occurs when

i. Receiver announces its empty space is zero

ii. Sender/client generates only one byte at a time.

iv. Receiver consumes one byte at a time

13. **Ans: (b)**

Sol: Total data size = 38400 bytes

8000 bytes per tick

1 → 8000 bytes

X ← 38400 bytes

$$= \frac{38400}{8000} = 5$$

14. **Ans: (a)**

Sol: Burst length = 5 sec

Token bucket capacity C = 1 million bytes

Token arrival rate ρ = 10 million bytes/sec

Maximum transmission rate

M = 50 million bytes

The number of bytes in a maximum speed burst of length S seconds is μs C + ρs = μs

$$S = C/(\mu - \rho s) = \frac{1 \text{ million bytes}}{(50-10) \text{ million bytes/sec}}$$

$$= \frac{1}{40} \text{ sec} = 25 \text{ m sec}$$

15. **Ans: (c)**

Token bucket rate = 1 Mbps

Full transmission rate = 5 Mbps

Capacity = 6 Mb

$$= \frac{\text{capacity}}{(\text{Full transmission rate} - \text{transmission rate})}$$

$$= \frac{6}{(5-1)} \text{ sec} = 1.5 \text{ sec}$$

16. **Ans: (b)**

Sol: Data in each packet

= maximum size – TCP header –IP header

= 1500 – 20 – 20 = 1460 bytes

$$\text{number of blocks} = \frac{1.5 \times 10^6 \text{ bytes}}{1460 \text{ bytes}} = 1028$$

$$\text{overhead} = \frac{1028 \times 1500 - 1.5 \times 10^6}{1.5 \times 10^6}$$

$$= \frac{42000}{1.5 \times 10^6} = 0.028 = 2.8\%$$

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17. Ans: (b)

Sol: IRTT = 30 msec

NRTT = 26 msec

$\alpha = 0.9$

$D_i = 5$

new deviation $D_N = |IRTT - NRTT|$

$= |30-26| = 4$ msec

1. ERTT = α IRTT + $(1-\alpha)$ NRTT

   IRTT = 0.9 * 30+0.1*26 = 29.6

2. NRTT = 32

   ERTT = α 1RTT + $(1-\alpha)$ NRTT

   = 0.9 * 29.6+0.1* 32=29.84

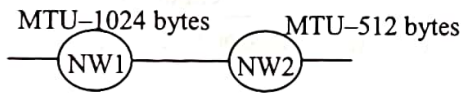
3. NRTT = 24

   ERTT = 0.9 * 29.84 + 0.1 * 24

   = 29.256 msec

18. Ans: (c)

Sol:



Message size = 2048 bytes

TCP header = 20 bytes

Total = 2068 bytes

First network MTU = 1024

Data size = 1024 – 14 = 1010 bytes

IP header = 20 bytes

Data size in IP = 1010–20 = 990 bytes

990 not multiple of 8 consider 984 bytes as

data: 984 + 984 + 100 = 2068

Data	(1) 984	(2) 984	(3)100
	+	+	+
header	20	20	20
offset	0	123	246

19. Ans: (c)

Sol: 3 fragments are from first network

3 fragments are passed to second network

Second network MTU = 512 bytes

Header = 8 bytes

Data can be allowed = 512 – 8 = 504 bytes

IP header = 20 bytes

Without header = 484 bytes

484 is not multiple of 8 consider 480 bytes

1. fragment data size = 984 bytes

   Fragmentation:

Data	(1) 480	(2) 480	(3)24
	+	+	+
Header	20	20	20
Offset	0	60	120

2. fragment data size = 984 bytes

   Fragmentation

Data	(4) 480	(5) 480	(6)24
	+	+	+
IP header	20	20	20
Offset	123	183	243

3. fragment data size = 100 bytes

   Need not fragment

   Total 7 fragments 5th fragment offset = **183**

20. Ans: (a)

21. Ans: (b)

Sol: Ethernet payload = 1466 bytes

Ethernet header = 26 bytes

IP header = 20 bytes

TCP header = 20 bytes

$\Rightarrow$ TCP payload = 1466 – (26 + 20 + 20)

= 1400 bytes

Number of packets per second = 10

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Total TCP payload sent

$= 10 \times 1400 \times 8$ bits /s $= 14000 \times 8$bits/s

$= 112000$ bits/s $= 112$ Kbps

22. Ans: (b)

Sol: Effective window = Advertised window – (Last Byte Sent – Last Byte Acked)

23. Ans: (b)

Sol: $B = 45$ Mbps $= 45 \times 10^6$ bps

Sequence number bits = 32

$$1 \text{ sec} \rightarrow \frac{45 \times 10^6}{8} \text{ bytes}$$

$$? \leftarrow 2^{32} \text{ bytes}$$

$$= \frac{2^{32} \times 8}{45 \times 10^6} = 12.72 \text{ min}$$

24. Ans: (d)

Sol: The sender may not send more than 255 TPDUS

Maximum data rate per connection

$$= \frac{128 \times 8 \times 255 \text{ bits}}{30 \text{ sec}}$$

$= 8.7$ KBPS

25. Ans: (c)

Sol: TCP Pseudo Header consist of S.A, D.A, Protocol and TCP segment field

S.A $\rightarrow$ 4 bytes

D.A $\rightarrow$ 4 bytes

Protocol & TCP segment $\rightarrow$ 4 bytes

Total = 12 bytes

26. Ans: (c)

Sol: The average throughput

$= (3*W/4) * MTU/RTT$

$= (0.75 * W * MTU)/ RTT$

$= (0.75 * W * MSS)/ RTT$

27. Ans: (b)

Sol: $\alpha = 0.9$

IRTT = 30 msec

NRTT = 40 msec

$ERTT = \alpha IRTT + (1-\alpha)\, NRTT$

$= 0.9 \times 30 + (1-0.9)\, 40$

$= 27 + 4 = 31$ msec

28. Ans: (c)

Sol: Identity field = 16 bits

We can send 576×2^{16} bytes per 60 sec

$$= \frac{576 \times 2^{16} \times 8}{60} = 5 \text{ Mbps}$$

29. Ans: (a)

Sol: IRTT = 30 msec

NRTT = 40 msec

$D_I = 5$ msec

$\alpha = 0.9$

$D_N = |\, IRTT - NRTT \,| = 10$ msec

$ERTT = \alpha\, IRTT + (1-\alpha)\, NRTT$

$= 31$ msec

$D_E = \alpha D_I + (1-\alpha)\, D_N = 5.5$ msec

Timeout $= 4 \times D_E + ERTT$

$= 4 \times 5.5 + 31$

$= 53$ msec

30. Ans: (a)

Sol: Bind ( ) $\rightarrow$ uses port number and IP

31. Ans: (b)

Sol: During slow start phase, congestion window is increased by one for each acknowledgment. Present window size is 8 packets as 8 acknowledgments are received. Therefore next size is 16 packets.

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32. Ans: (d)

Sol: New RTT= 0.9 × 30 msec + 0.1 × 26 msec
= 29.6

Estimated deviation = 0.9 × 4 + 0.1 × 4
= 4 In Jacobsons algorithm timeout
= 4 × 4 + 29.6
= 45.6 msec

In basic algorithm Timeout = 2 × 29.6 msec
= 59.2 msec

33. Ans: (c)

Sol: Since TCP is combination of two half duplex connection both client and server have their own data transmission connections and they write to these connections.

34. Ans: (d)

Sol: Since Don't Fragment (DF) bit is 1, network is not allowed to fragment datagram.

35. Ans: 24000 bytes

Sol: If we transfer 12,000 bytes (4 packets) then we get 4 acknowledgements, as per TCP congestion control for each ACK window is increased by 1 MSS therefore for 4 ACKs it would be 24,000 bytes.

36. Ans: (b)

Sol: Once timeout occurs, congestion window is set to one MSS (4KB) and threshold value is set of half of the congestion window at timeout (32KB).

Now window is increases exponentially upto threshold value (8KB, 16KB, 32KB) it takes 240 msec. After thresholds value it increases linearly (36KB, 40KB, 44KB 48KB, 52KB, 56KB, 60KB, 64KB) it takes 8*80 = 640 msec.

Total time = 240 +640 = 880msec

37. Ans: (b)

Sol: $\alpha = 0.9$

IRTT = 20 msec

NRTT = 24 msec

New RTT = α IRTT + $(1-\alpha)$ NRTT
= 0.9 * 20 +0.1 * 24
= 20.4 msec

IRTT = New RTT = 20.4 msec

NRTT = 19 msec

New RTT estimate = 0.9 * 20.4 +0.1 *19
= 18.36 + 1.9 = 20.26

38. Ans: (a)

Sol: $$\text{Throughput} = \frac{1\text{window}}{\text{RTT}} = \frac{32767}{10\text{msec}} = \frac{32767*8}{10\text{msec}} = 26.2136 \text{ mbps}$$

$$\text{line efficinecy} = \frac{\text{throughput}}{\text{Bandwidth}} = \frac{26.2136}{512} = 0.05119 = 5.119\%$$

39. Ans: (c)

Sol: 1st transmission $\xrightarrow{1}$

2nd transmission $\xrightarrow{2}$

3rd transmission $\xrightarrow{4}$

4th transmission $\xrightarrow{8}$.

40. Ans: (c)

Sol: 1 min = 60 sec → 100 gal

12 min → x?

$$x = \frac{100 \times 12}{60} = 20 \text{ gal}$$

Input = 5 gal

Output = 20 gal

Capacity = 20 – 5 = 15 gal

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Chapter 7 Application Layer Protocols

Domain Name System

01. Which of the following is ***false*** about DNS?
(a) DNS is a client server application
(b) DNS uses the services of UDP for the messages of <512 B, Otherwise TCP.
(c) DNS tree can have only 64 levels
(d) DNS organizes the name space in a hierarchical structure.

02. Which attribute in resource record is used to deal with DNS cache issues at clients?
(a) MX (b) TTL
(c) CNAME (d) A

03. A resource record of DNS has Time to live field which gives the indication of how stable the record is. Such information which is highly stable is assigned to?
(a) 68400 (b) 86600
(c) 84600 (d) 86400

Hyper Text Transfer Protocol

04. Match the Following:

Application layer protocols	Port No.
W: FTP data	1. 80
X: FTP control	2. 20
Y: HTTP	3. 23
Z: TFTP	4. 21
	5. 25
	6. 69

Codes:
(a) W-1, X-4, Y-1, Z-2
(b) W-2, X-4, Y-1, Z-6
(c) W-4, X-6, Y-1, Z-2
(d) W-4, X-2, Y-1, Z-6

File Transfer Protocol

05. Which HTTP method allows the client to see what is being received at the other end of the request chain and use that data for testing or diagnostic information?
(a) Connect (b) Options
(c) Head (d) Trace

06. TELNET is using the character mode, characters are sent back and forth between the client and server and in a handshake there is IAC which means
(a) Internet ASCII command
(b) Internet ASCII Character
(c) Interpret As Command
(d) Interpret ASCII Character

Simple Mail Transfer Protocol

07. The protocol(s) that uses a connectionless UDP.
(a) SNTP (b) POP3
(c) FTP (d) DNS

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08. Which resource record is used by SMTP (Simple Mail Transfer Protocol) to locate hosts that will process or forward mail for the domain, along with preference values for each mail exchanger host?

(a) CNAME (b) A
(c) MX (d) NS

09. Which protocol is connection oriented asynchronous protocol?

(a) FTP (b) SMTP
(c) HTTP (d) DNS

10. Match the following:

1.HTTP	i. Uses both TCP and UDP
2. FTP	ii. Uses two ports for its operation
3. DNS	iii. MIME to deal with non ASCII data
4.SMTP	iv. Used to get the mail
5. POP3	v. TRACE method loop back request message

(a) 1-i, 2-ii, 3-iii, 4-iv, 5 –v
(b) 1-i, 2-iii, 3-ii, 4-v, 5 –iv
(c) 1-iv, 2-ii, 3-iii, 4-i, 5 –v
(d) 1-v, 2-ii, 3-i, 4-iii, 5 –iv

11. At which three layers of the OSI model does telnet primarily work:

(a) Application layer, Session layer, Transport layer.
(b) Presentation layer, Session layer, Transport layer.
(c) Datalink layer, Transport layer, Presentation layer.
(d) Presentation layer, Application layer, Session layer.

12. Which of the method allows the client to determine requirements associated with a resource, or the capabilities of a server, without implying a resource action or initiating resource retrieval?

(a) POST (b) Delete
(c) Options (d) Trace

13. Match the following:

List 1: (Protocols)	*List2: (Port number)*
(P) DNS	(1) 23
(Q) DHCP	(2) 53
(R) IMAP	(3) 67
(S) POP3	(4) 68
	(5) 110
	(6) 143

Codes:

(a) P – 3, Q – 4, R – 5, S – 6
(b) P – 2, Q – 3, R – 5, S – 6
(c) P – 2, Q – 4, R – 6, S – 5
(d) P – 1, Q – 3, R – 6, S – 5

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Solutions

Domain Name System

01. Ans: (c)

Sol: According to the DNS properties a, b, d are true.

02. Ans: (b)

Sol: This is a CNAME DNS Record.

03. Ans: (d)

Sol: TTL: gives how stable the DNS record is
(1 day) 86400 is high stability
(1 min) 60 is low stability

Hyper Text Transfer Protocol

04. Ans:(b)

Sol: FTP data – 20 (port)
FTP control – 21
HTTP – 80
TFTP – 69

File Transfer Protocol

05. Ans: (d)

Sol: **Trace:** Echo's back the received request, so that a client can see what intermediate server are adding or changing in the request

06. Ans:(c)

Sol: IAC → Interpret As command

Simple Mail Transfer Protocol

07. Ans: (d)

Sol: Both SNMP and DNS uses UDP protocol

08. Ans: (c)

Sol: 1. CNAME → canonical Name
(Name: Alias Name)
2. A → Address where
Name = Host name
Value = IP address
3. MX → Mail Exchange
Name = Domain Name
Value = Name of mail server
4. NS → Name service
Name = Domain Name
Value = Host Name of Authoritative DNS server.

09. Ans: (b)

10. Ans: (d)

Sol: DNS use UDP for the messages of < 512 B, other cases TCP HTTP for trace.
FTP → used two ports, one port at client another port at server

11. Ans: (d)

Sol: Top 3 layers of OSI.

12. Ans: (c)

13. Ans: (c)

Sol: Protocol–port number
DNS – 53
DHCP – 68
IMAP – 143
POP3 – 110

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Chapter 8 Network Security

01. Encode the following bit stream into base 64 encoding: 110010101111000001110010

(a) Y v D Y (b) v Y D v

(c) Y v B Y (d) V y B V

02. Convert the following bit stream using base 64 encoding.

10100011 00110111 11101001 10101011

(a) ozfpq (b) zdfpq

(c) qwApq (d) oAfpq

03. Match the following:

List - I (Security Principle)

(P) Confidentiality

(Q) Authentication

(R) Integrity

(S) Availability

List – II (Attacks)

(1) Interruption

(2) Modification

(3) Interception

(4) Fabrication

Codes:

(a) P–3, Q–2, R–4, S–1

(b) P–3, Q–2, R–1, S–4

(c) P–2, Q–3, R–4, S–1

(d) P–3, Q–4, R–2, S–1

04. RSA algorithm is used and p = 17 and q = 11 and public key pair (e, n) is given as (7,187). Find the secret key, d =?

(a) 11 (b) 15

(c) 19 (d) 23

05. What is the inverse of following initial permutation of DES algorithm:

IP(5,0,7,2,1,6,4,3)

(a) IP^{-1}(6, 0, 5, 2, 1, 4, 3, 7)

(b) IP^{-1}(1, 4, 3, 2, 7, 6, 0, 5)

(c) IP^{-1}(1, 4, 3, 7, 6, 0, 5, 2)

(d) IP^{-1}(6, 0, 5, 2, 3, 7, 4,)

06. RSA public key cryptography is used and p = 7 and q = 11 and public key pair (e, n) is given as (13, 77). Find the secret key, d =?

(a) 11 (b) 17

(c) 37 (d) 43

07. Suppose that two parties A and B wish to setup a common secret key between themselves using the Diffie-Hellman key exchange technique. They agree on 23 as the modulus and 7 as the primitive root. Party A chooses 3 and party B chooses 6 as their respective secret keys their D-H key is.

(a) 21 (b) 4

(c) 35 (d) 18

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08. Using the RSA algorithm, encrypt the plain text '5' if the following values are given
$p = 7, q = 11, c = 13, d = 37$
(a) 26 (b) 28
(c) 63 (d) 65

09. RSA algorithm is used with prime numbers 101 and 103 to generate public keys and private keys. If the 'e' value is chosen as '3', then encrypt the message m = 9876
(a) 512 (b) 7027
(c) 2048 (d) 4096

10. Using the RSA algorithm, with p =3, q = 11, d = 7, find the ciphertext character corresponding to the plaintext Character 'N' using the numbers corresponding to the letters, e.g., the number 1 stands for 'A'.
(a) 5 (b) 6
(c) 11 (d) 13

11. Suppose that two parties A and B wish to setup a common secret key between themselves using Diffie-Hellman key exchange technique. They agree on 23 as the modulus and 5 as the primitive root. Party A chooses 6 and party B chooses 15 as their respective secrets. Their D-H key is:
(a) 2 (b) 3
(c) 4 (d) 5

12. Match the following:

List-1(Security Goals)
(P) Confidentiality
(Q) Availability
(R) Integrity

List-2 (Security attacks)
(1) Denial of service
(2) Modification
(3) Traffic Analysis
(4) Spoofing

Codes:

	P	Q	R
(a)	1	2	3
(b)	4	2	2
(c)	3	4	1
(d)	4	1	2

13. The Diffie–Hellman key exchange is used to establish a session between the users A and B with the values of p = 23, primitive root g = 7 and private keys of users A and B are $X_A = 5$, $X_B = 8$ then the session key between A and B is _____.
(a) 18 (b) 25
(c) 22 (d) None

14. Advanced Encryption Standard (AES) is based on
(a) Asymmetric key algorithm
(b) Symmetric key algorithm
(c) Public key algorithm
(d) Key exchange

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Common Data For Q 15, Q 16 and Q17:

The Diffie - Hellman key exchange is being used to establish a session key between the sender and the receiver with the values of $n = 719$, $g = 3$

15. If the sender's secret number is $x = 16$, then it transmits the message (719, 3, ____) fill in the blank.
    (a) 412 (b) 111
    (c) 543 (d) 191

16. If receiver's secret number is 15, then calculate the receiver's respond?
    (a) 412 (b) 111
    (c) 543 (d) 191

17. RSA algorithm is used by choosing two prime numbers $p = 5$, $q = 11$, if the public key $e = 7$ then the private key d = _____
    (a) 21 (b) 23
    (c) 20 (d) None

18. RSA public key cryptography is used and $p = 13$ and $q = 7$ and public key pair (e, n) is given as (5,91). If we want to encrypt the following messages containing the values, then what are the cipher values?
    (i) The message containing the value 6, then find the cipher value, calls it 'a'
    (ii) The message containing the value 7, then find the cipher value, calls it 'b'
    (iii) The message containing the value 8, then find the cipher value, calls it 'c'
    (iv) The message containing the value 9, then find the cipher value, call it 'd'

    (a) $c < a < b < d$ (b) $a < b < c < d$
    (c) $d < a < b < c$ (d) $d < b < c < a$

19. The Denial of Service (DOS) is attack on _____.
    (a) Authentication (b) Availability
    (c) Confidentiality (d) Integrity

20. RSA Algorithm is uses by choosing two prime numbers $p = 7$, $q = 13$ and public key $e = 2$, then the value of d = ?
    (a) 18 (b) 31
    (c) 35 (d) None

21. Which of the following are used to generate a digital signature by the following combination of network security protocols?
    (P) RSA (Q) SHA – 1
    (Q) DES (S) MD5

    (a) P and Q (b) R and Q
    (c) R and S (d) Q and S

22. Diffie–Hellman algorithm provides Service
    (a) Digital Signature
    (b) Encryption/Decryption
    (c) Key Exchange
    (d) All of these

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23. Which of the following protocols provides Authentication Service?
(a) Symmetric key CryptoSystem
(b) Public key CryptoSystem
(c) MAC
(d) All of these

24. ____ Algorithm is vulnerable to Man–In the Middle Attack
(a) Diffie–Hellman (b) RSA
(c) DES (d) None

25. The Diffie–Hellman uses the global parameters p = 23. Primitive root a = 7 and the sender's secret key X_A = 7 then it transmits the message _____.
(a) 4 (b) 5
(c) 21 (d) 15

26. RSA Algorithm is used with p = 7, q = 11 and e = 11, d = 6 then encrypt M = 5_____.
(a) 38 (b) 68
(c) 24 (d) 45

27. The number of rounds in Triple DES with Two distinct keys is:
(a) 16 (b) 32
(c) 48 (d) 64

28. The size of SHA–1 message digest
(a) 256 (b) 160
(c) 512 (d) 384

29. What would be used to share a single public address within a company?
(a) NAT
(b) PAT(Port Address Translation)
(c) VLSM
(d) Private Addressing and NAT

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Solutions

01. Ans: (c)

Sol: Divide into groups of 6 bits each

|110010|101111|000001| 110010|

Convert into decimal then replace decimal by corresponding character 50, 47, 1, 50

A – 0,.....Z – 25, a – 26, Y – 50, Z – 51

Y v BY

02. Ans: (a)

Sol: Divide into 4 groups each of 6 bits

	101000	110011	011111	101001	101010
decimal:	40	51	31	41	42
	o	z	f	p	q

ozfpq

base – 64 has 64 characters

A–0, B–1,.....Z–25, a–26, b–27,.....z–51, 0–51, 1–53,... 9–61, +62, 1– 63

03. Ans: (d)

Sol: **Interception** – disclosure of secrecy (confidentiality)

Fabrication–impersonation(authentication)

Modification – modification of partial data, fully, deletion (Integrity)

Interruption – Blocking (Availability)

04. Ans: (d)

Sol: RSA

$n = p \times q = 187$

$\phi(n) = 160$

$e = 7$

$d = e^{-1} \bmod \phi(n) = 7^{-1} \bmod 160$

$d = 23$

$e \times d = 1 \bmod 160$

05. Ans: (c)

Sol: Go through DES initial permutation and inverse initial permutation.

06. Ans: (c)

Sol: RSA Algorithm

$p = 7, q = 11, n = 77,$

$\phi(n) = (p-1) \times (q-1)$

$= 60, e = 13$

$e \times d = 1 \bmod \phi(n)$

$13 \times d = 1 \bmod 60$

$\Rightarrow$ d is the inverse of e mod 60

(a) $13 \times 11 = 143 \bmod 60 = 23 \neq 1$

(b) $13 \times 17 = 221$ mode $60 = 41 \neq 1$

(c) $13 \times 37 = 481$ mode $60 = 1 \Rightarrow d = 37$

07. Ans: (d)

Sol: Diffie Hellman Key Exchange Algorithm

$p = 23$, primitive root $a = 7$

A's private Key $X_A = 3$

B's private Key $X_B = 6$

A's public Key $Y_A = a^{X_A} \bmod P$

$= 7^3 \bmod 23 = 21$

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$(Y_B)^{X}A \bmod 23$

Secret key: $4^3 \bmod 23 = 64 \bmod 23 = 18$

B public key $= 7^6 \bmod 23 = 4$

08. **Ans: (a)**

Sol: $p = 7, q = 11, e = 13, d = 37$

$n = p * q = 77$

message $m = 5$

cipher text $c = m^e \bmod n$

$= 5^{13} \bmod 77 = 5^5 * 5^5 * 5^3 \bmod 77$

$= 45 * 45 * 48 \bmod 77 = 26$

09. **Ans: (b)**

Sol: RSA: $p = 101, q = 103$

$n = p \cdot q = 10403$

$\phi(n) = 10200$

$e = 3$

message $m = 9876$

Encryption $c = M^e \bmod n$

$= 9876^3 \bmod 10403 = 7027$

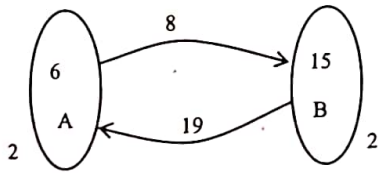
10. **Ans: (a)**

Sol: **Hint:** $e = 3$

N is 14 $\quad 143 \bmod 33 = 5$

11. **Ans: (a)**

Sol:



12. **Ans:(d)**

13. **Ans: (a)**

Sol: $Y_A = g^{XA} = 7^5 \bmod 23 = 17$

$Y_B = g^{XB} = 7^8 \bmod 23 = 12$

$K_{AB} = Y_A^{XB} = 17^8 \bmod 23 = 18$

14. **Ans: (b)**

Sol: Advanced Encryption Standard (AES) is a specification for the encryption of electronic data. It has been adopted by the U.S. government and is now used worldwide. It supersedes DES. The algorithm described by AES is a symmetric-key algorithm, meaning the same key is used for both encrypting and decrypting the data.

15. **Ans: (d)**

16. **Ans: (c)**

17. **Ans: (b)**

Sol: $n = 5 \times 11 = 55$

$\phi(n) = 40$

$e = 7$

$d = 23$

18. **Ans: (a)**

19. **Ans: (b)**

Sol: Flooding of bogus messages or Destruction of communication.

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20. Ans: (d)

Sol: $e = 2, e * d = 1 \bmod \phi(n) = 72$

$2 * d = 1 \bmod 72$

d is inverse of 2 but inverse is not possible as $\gcd(2, 72) = 2$

21. Ans: (a)

Sol: (a) is correct. For digital signature creation use Authentication algorithm then public key algorithm.

P and Q/ P and S are correct

22. Ans: (c)

Sol: Diffie–Hellman only provides key Exchange Service.

23. Ans: (c)

Sol: Symmetric key, public key CryptoSystems provides authentication, Symmetric key CryptoSystem shares the key.

Public key CryptoSystem uses private key for encryption, public key for Decryption

MAC – Message Authentication code is a one–way function which provides authentication.

24. Ans: (a)

25. Ans: (b)

Sol: Public key $Y_A = a^{X_A} \bmod p$

$= 7^7 \bmod 23 = 5$

26. Ans: (a)

Sol: $C = M^e \bmod n = 5^{11} \bmod 77 = 38$

27. Ans: (c)

Sol: DES uses – 16 rounds and Triple DES uses DES 3 times.

$\therefore$ 48 rounds

28. Ans: (b)

29. Ans: (b)

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Algorithms

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Chapter 1 Algorithm Analysis & Asymptotic Notations

01. Consider the following two functions:

$$g_1(n) = \begin{cases} n^3 & \text{for } 0 \le n \le 10{,}000 \\ n^2 & \text{for } n \ge 10{,}000 \end{cases}$$

$$g_2(n) = \begin{cases} n & \text{for } 0 \le n \le 100 \\ n^3 & \text{for } n > 100 \end{cases}$$

Which of the following is **true**?

(a) $g_1(n)$ is $O(g_2(n))$

(b) $g_1(n)$ is not $O(g_2(n))$

(c) $g_2(n)$ is $O(g_1(n))$

(d) $g_2(n)$ is $O(n)$

02. The Average case and worst case complexities for Merge sort algorithm are

(a) $O(n^2)$, $O(n^2)$

(b) $O(n^2)$, $O(n \log_2 n)$

(c) $O(n \log_2 n)$, $O(n^2)$

(d) $O(n \log_2 n)$, $O(n \log_2 n)$

03. The time complexity of the following C function is (assume n > 0)

```
int recursive (int n)
{
    if (n == 1)
      return(1);
    else
      return(recursive (n–1) + recursive (n–1));
}
```

(a) $O(n)$ (b) $O(n \log n)$

(c) $O(n^2)$ (d) $O(2^n)$

04. Consider the following functions

$f(n) = 3n^{\sqrt{n}}$

$g(n) = 2^{\sqrt{n}} \log_2 n$

$h(n) = n!$

Which of the following is **true**?

(a) h(n) is O(f(n)) (b) h(n) is O(g(n))

(c) g(n) is not O(f(n)) (d) f(n) is O(g(n))

05. Consider the following three claims:

I. $(n + k)^m = O(n^m)$, where k and m are constants

II. $2^{n+1} = O(2^n)$

III. $2^{2n} = O(2^n)$

Which of these claims are **correct**?

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

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

6. Let f(n), g(n) and h(n) be functions defined for positive integers such that

$f(n) = O(g(n))$,

$g(n) \neq O(f(n))$,

$g(n) = O(h(n))$, and $h(n) = O(g(n))$

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

(a) $f(n) + g(n) = O(h(n)) + h(n)$

(b) $f(n) = O(h(n))$

(c) $h(n) \neq O(f(n))$

(d) $f(n)h(n) \neq O(g(n)h(n))$

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07. Which of the following is *false?*

(a) 100 n logn = O (n log n / 100)

(b) $\sqrt{\log n}$ = O (log log n)

(c) if $0 < x < y$ then $n^x = O(n^y)$

(d) $2^n \neq O(n^k)$

08. Two alternative packages A and B are available for processing a database having 10^k records. Package A requires $0.0001n^2$ time units and package B requires $10n \log_{10} n$ time units to process n records. What is the smallest value of k for which package B will be preferred over A?

(a) 12 (b) 10

(c) 6 (d) 5

09. Consider the following C code segment

```
int IsPrime(n)
{
    int i,n;
    for(i=2;i <= sqrt(n); i++)
    if (n % i = 0)
    {
        printf ("Not Prime\n");
        return 0;
    }
    return 1;
}
```

Let T(n) denote the number of times the for loop is executed by the program on input n. Which of the following is **TRUE**?

(a) $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(\sqrt{n})$

(b) $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(1)$

(c) $T(n) = O(n)$ and $T(n) = \Omega(\sqrt{n})$

(d) None of these

10. The minimum number of comparisons required to determine if an integer appears more than n/2 times in a sorted array of n integers is

(a) $\Theta(n)$ (b) $\Theta(\log n)$

(c) $\Theta(\log_2 n)$ (d) $\Theta(1)$

11. A ternary search, searches an ordered list for given element by successively dividing the list into thirds and determining in which third the element must lie. The complexity of the algorithm is

(a) O(n) (b) $O(\log_2 n)$

(c) $O(\log_3 n)$ (d) $O(n^2)$

12. Rahul has an Algorithm X for a problem with time complexity X that is polynomial over the input size. Rahim has an algorithm Y for another problem with time complexity Y, that is an exponential over the input size and David has an algorithm Z for another problem with time complexity Z that is double exponential over the input size. Which is correct?

(a) $\Theta(X) = \Theta(Y)$

(b) $\Theta(X) = \Theta(Z)$

(c) $\Theta(Y) = \Theta(Z)$

(d) $O(Z) = X$

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13. Consider the following program fragment:

```
count = 1;
for (i =1; i <=n; ++i)
{
    if (x[i]= =1) count++;
    else
    {
        f(count) ;
    }
}
```

Given that x[1...n] is a Binary array where each element takes a value of either 0/1. The function f(m) is O(m). Complexity of the program segment in the worst case is

(a) $O(n^2)$ (b) $O(1)$
(c) $O(n^3)$ (d) $O(n)$

14. Consider the following Pseudo code of recursive function Do-it.

```
Do-it(integer a, integer N)
{
  if(N= =1) return a;
  else
    return(a + Do-it(a,N/2));
}
```

The number of times the function Do-it is recursively executed is

(a) $\Theta(\log N)$ (b) $\Theta(N)$
(c) $\Theta(1)$ (d) $\Theta(N \log N)$

15. Suppose that a problem A reduces to problem B and the reduction is done in $O(n^2)$ time. If the problem is solved in $O(n^3)$ time. What about the time of problem A?

(a) $O(n^2)$ (b) $O(n^3)$
(c) $O(2^n)$ (d) $O(n^5)$

16. The height of a binary tree having 'i' nodes at level 'i' considering root to be at level '1' is _____, 'n' being the total number of nodes in tree

(a) O(logn) (b) O(n)
(c) $O(\sqrt{n})$ (d) $O(n^2)$

17. Consider the following functions:

$f_1 = n^{4/3}$; $f_2 = 2^{2^n}$; $f_3 = 2^{n^2}$; $f_4 = n!$; $f_5 = 2^n$

Which of the following is true?

(a) f_1 is $\Omega(f_2)$
(b) f_2 is $O(f_3)$
(c) $f_1 < f_5 < f_4 < f_2 < f_3$
(d) f_4 is $O(f_3)$

18. Consider the following program segment

```
Count = 0;
for i ← 1 to n
{
    M = ⌊ n/i ⌋;
    for j ← 1 to m
    count = count + 1;
}
```

The order of magnitude of the program segment is

(a) O(n log n) (b) O(n)
(c) $O(n\sqrt{n})$ (d) None

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19. What is the time complexity of the following program?

```
void sum(int n)
{
    int i, j, c = 0;
    for (i = 1; i ≤ n; i++)
    {
        for (j = 1; j * j ≤ n; j++)
        c++;
    }
}
```

(a) $O(n)$ (b) $O(\log n)$
(c) $O(\sqrt{n})$ (d) $O(n\sqrt{n})$

20. Consider the following three claims:

I. $(n+3)^3 = O(n^3)$
II. $3^{n+1} = O(3^n)$
III. $2^{2n} = O(2^n)$

Which of these claims are **correct**?

(a) I and II (b) I and III
(c) II and III (d) I, II and III

21. The Recurrence equation of the following algorithm is

```
Algorithm A (n)
if n <= 2
    return (1);
else
    return (a [√n] );
```

(a) $T(n)=T(\sqrt{n}) + 1$ (b) $T(n)=T(\sqrt{n}) + n$
(c) $T(n)=T(n) + n$ (d) $T(n)=T(n/2) + n$

22. The running time of the following algorithm

```
procedure A(n)
{
    if (n <= 2)
        return (1);
    else
        return A(√n);
}
```

is best described by

(a) $O(n)$ (b) $O(\log 2^n)$
(c) $O(\log_2 \log_2 n)$ (d) $O(1)$

23. The time complexity of the following C function is (assume $n > 0$)

```
int ACE(int n)
{   if(n == 1)
        return(1)
    else
        return (ACE (n–1) +ACE(n–1))
}
```

(a) $O(n)$ (b) $O(n(\log_2 n))$
(c) $O(n^2)$ (d) $O(2^n)$

24. A certain algorithm A has been shown to have running time $O(N^{2.5})$, where N is the size of the input which of the following is **not true** about algorithm A?

(a) There exist constants C_1 and C_2 such that for all N, the running time is less than $C_1 N^{2.5} + C_2$.
(b) For all N, there may be some inputs for which the running time is less than $N^{2.4}$.

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(c) For all N, there may be some inputs for which the running time is more than $N^{2.4}$.

(d) For all N, there may be some inputs for which the running time is more than $N^{2.6}$.

25. If $f(n) = 2^n$ then $O(f(n))$ is

(a) $O(n!)$ (b) $O(n^2)$

(c) $O(n)$ (d) $O(n^3)$

26. Which of the following statement is ***true***?

(a) $n^n = O(2^n)$

(b) if $f(n) = O(g(n))$ then $g(n)$ is $O(f(n))$

(c) if $f(n) = O(g(n))$ then $g(n) = \Omega(f(n))$

(d) if $f(n) = \Theta(g(n))$ then $2^{f(n)}$ is $\Theta(2^{g(n)})$

27. Consider the functions given below:

$f(n) = n$

$g(n) = n^{1+\sin x}$

(a) $f(n)$ is $O(g(n))$

(b) $f(n)$ is $\Omega(g(n))$

(c) $g(n)$ is $O(f(n))$

(d) None of the above

28. Consider the functions:

$f(n) = \log \log n$

$g(n) = \sqrt{\log n}$

$h(n) = n^2 \log n$

(a) $f(n)$ is $O(g(n))$ & $h(n)$ is $\Omega(g(n))$

(b) $g(n)$ is $O(f(n))$ & $h(n)$ is $O(g(n))$

(c) $h(n)$ is $O(f(n))$ & $g(n)$ is $O(f(n))$

(d) $f(n)$ is $O(g(n))$ & $h(n)$ is $O(g(n))$

29. Let $f(n)$, $g(n)$ be Two-functions and $f(n)$ is $O(g(n))$ then which one of the following statement is ***false*** ?

(a) $\log(f(n))$ is $O(\log g(n))$

(b) $2^{f(n)}$ is $O(2^{g(n)})$

(c) 2^{100} is $O(1)$

(d) n^n is $O(2^n)$

30. Let $T(n) = \sum_{j=1}^{n} \log_2 j$. Then which one of the following is ***true?***

(a) $T(n) = \Theta(\log_2 n)$ (b) $T(n) = \Theta(n \log_2 n)$

(c) $T(n) = \Theta(n^2)$ (d) $T(n) = \Theta(n)$

Statement for Q31 is given below.

Consider the following C fragment DAA()

```
void DAA( )
{
    int i,j,k,x=0;
    for(i=1; i<=n; i++)
    for(j=1; j<= i*i; j++)
    {
        if (j mod i == 0)
        for( k=1; k<=j; k++)
        x=x+10;
    }
}
```

31. Let the time complexity of the above fragment is $T(n)$ then which one of the following is **true** ?

(a) $T(n) = \Theta(n^2)$ (b) $T(n) = \Theta(n^3)$

(c) $T(n) = O(n^5)$ (d) $T(n) = \omega(n^5)$

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32. Let 'k' be an integer greater than 1. Which of the following represents the order of growth of the expression?

$\sum^{n} k^{i}$ is a function of n?

(a) $\Theta(k^n)$
(b) $\Theta(k^{n \log n})$
(c) $\Theta(k^n \log n)$
(d) $\Theta(n^{k+1})$

33. Which of the following claims is / are **true**?

I. $n^3 \log n$ is $\Omega(n^3)$
II. n^2 is $\omega(n)$
III. 2^{n+1} is $O(n^2)$
IV. f(n) is O(g(n)) iff g(n) is Ω (f(n))

(a) I, II & III
(b) I, II & IV
(c) I & II
(d) II, III & IV

34. Rigorous analysis of a particular algorithm has found that as the size of the input exceeds a certain constant m, its running time T(n) is, at most, proportional to the cube of the input, so that for all input 'n' such that 'n' exceeds the constant m, $T(n) \le c * n^3$ where 'c' is also a constant.

Which of these statements are **true**?

I. The constants m and c are witnesses to the fact that T (n) is $O(n^3)$
II. For an input of a given sizes 'n' the algorithm running time will be the same on any computer.
III. If for some values of n, $T(n) \ge O(n^3)$, we can still say T(n) is $O(n^3)$, but we must find new constants m & c for those values of n.

(a) I only
(b) II only
(c) II & III only
(d) I, II and III only.

35. Arrange the following in increasing asymptotic order:

P: $\sqrt{\log n}$
Q: n
R: $2^{\sqrt{\log n}}$
S: $\sqrt{n}$
T: 2^{2^n}

(a) P Q R S T
(b) Q P R S T
(c) P S Q R T
(d) P S R Q T

36. As $n \to \infty$, the function $2^{\sqrt{n}}$ grows faster than

(a) log n, but slower than $\sqrt{n}$
(b) $\sqrt{n}$, but slower than n
(c) n, but slower than n^2
(d) n^2, but slower than $\sqrt{2^n}$

37. Which of the following statements is/ are **true** using Big – oh notation

(a) $n! = O(2^n)$
(b) $2^n = O(n^2)$
(c) $\log n! = O(n \log n)$
(d) $n^2 = O(n+\log n)$

38. Which of the following is ***false***?

(a) $n^3 2^n + 6n^2 3^n = O(n^3 2^n)$
(b) $33n^3 + 4n^2 = \Omega(n^2)$
(c) $\sum_{i=0}^{n} i^2 = \Theta(n^3)$
(d) $n! = O(n^n)$

39. Consider the following claims:

I. $\log^x n$ is $O(n^y)$ $x > 0; y > 0$
II. $4 \log_2 n$ is $O(n^2)$
III. $4.n^{3/2}$ is $\Omega(n^2)$
IV. 10n logn is O(n logn)

Which of the above are **true**?

(a) I & II
(b) I, II & IIII
(c) I, II & IV
(d) I, II, IIII & IV

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40. $\prod_{1 \le K \le n} O(n)$, where O(n) stands for order n is :

(a) O(n) (b) $O(n^2)$

(c) $O(n^3)$ (d) $O(1.5n^2)$

41. Assume that X and Y are non zero positive integers. What does the following program segment do?

```
while X <> Y do
if X > Y then
    X: = X – Y;
else
    Y: = Y – X;
    write (X);
```

(a) Computes the LCM of two numbers

(b) Divides the larger number by the smaller number.

(c) Computes the GCD of two numbers.

(d) None of the above.

42. Which of the following statements is **false**? Let f(n) & g(n) be two functions & f(n) is O(g(n))

(a) log f(n) is O (log (g(n)))

(b) $2^{f(n)}$ is $O(2^{g(n)})$

(c) $(n + 1)^5$ is $O(n^5)$

(d) None of these

43. Calculate complexity for the following block

```
sum = 0
for (i = 1 to n) do
for ( j = 1 to i^2) do
if ( j mod i = = 0) then
for (k = 1 to j) do
sum = sum + 1
```

(a) $\Theta(n)$ (b) $\Theta(n^3)$

(c) $\Theta(n^4)$ (d) $\Theta(n^2)$

44. Suppose $T_1(N) = O(f(n))$ and $T_2(N)=O(f(n))$, then which of following claims are ***true***?

(i) $T_1(N) + T_2(N) = O(f(n))$

(ii) $T_1(N) / T_2(N) = O(1)$

(iii) $T_1(N) = O(T_2(N))$

(a) (i) only (b) (ii) only

(c) (i) & (iii) (d) (i), (ii), (iii)

45. An array 'A' contain 'I' number of Inversions then what is the Time Complexity of insertion sort algorithm to sort 'n' element of array 'A'?

(a) O(n + I) (b) $O(n^2 + I)$

(c) $O(n^3 + I)$ (d) $O(n^4 + I)$

46. Given two sorted arrays containing a total of 'n' elements, what is the Time Complexity of finding median of 'n' elements?

(a) O(n log n) (b) $O(n^2)$

(c) O(log n) (d) $O(2^n)$

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Solutions

01. Ans: (a)

Sol: $g_1(n)$ is $O(g_2(n))$, whenever $n>100$.

02. Ans: (d)

Sol: Performance

Worst case complexity: $O(n \log n)$

Best case complexity: $O(n \log n)$

Worst case space complexity: $O(n)$

03. Ans: (d)

Sol: The recurrence for the given problem is

$T(n) = 1, \quad n = 1$

$= 2.T(n-1) + 1$

Solving it with Back-substitution, it is $O(2^n)$.

04. Ans: (c)

Sol: Take Logs of the functions and find that f(n) is O (g(n)).

$g(n) \le f(n) \le h(n)$.

05. Ans: (a)

Sol: $(n+k)^m$ is a polynomial of power m

$\therefore O(n^m)$ is true.

$2^{n+1} = O(2^n.2)$

$= O(2^n)$

$\therefore$ It is true.

$2^{2n} = O(2^n.2^n)$

$\neq O(2^n)$

I and II only are correct.

06. Ans: (d)

Sol: Here, $f(n) < g(n) = h(n)$

Option a: $f(n)+g(n) = O(h(n))+h(n)$

$(\because f(n) = O(h(n)) \ \& \ g(n) = h(n))$

$\Rightarrow$ True

Option b: lower = O(higher)

$\Rightarrow f(n) = O(h(n)) \Rightarrow$ True

Option c: $h(n) \neq O(f(n)) \Rightarrow$ True

Option d: $f(n).h(n) \neq O(g(n).h(n)) \Rightarrow$ False, $g(n).h(n)$ will always have higher growth rate than $f(n).h(n)$

07. Ans: (b)

Sol: **Option a:** $100 \, n \log n = O(n \log n / 100)$

$= O\left(\frac{n \log n}{100}\right)$ ($\because$ 100 is constant)

$\Rightarrow$ True

Option b: $\sqrt{\log n} = (\log n)^{1/2} \rightarrow$ (True)

$= \frac{1}{2} \log n$

$= O(\log n)$

Which is not $O(\log \log n)$

$\Rightarrow$ (False)

Option c: $0<x<y$

Let $x=3, y=5$

$n^3 = O(n^5)$

lower = O(higher)

$\Rightarrow$ True

Option d: $2^n \neq O(n^k)$

Here, 2^n is higher growth rate function than n^k.

$\Rightarrow$ True

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08. Ans: (c)

Sol: For k=5, the value of $0.0001n^2$ is less than $10\ n \log_{10} n$ however for k=6 $0.0001n^2$ is greater than $10\ n \log n$

09. Ans: (b)

Sol: The loop will not be executed more than $\sqrt{n}$ times, upper bound will not be more than $\sqrt{n}$. Lower bound is $\Omega(1)$.

10. Ans: (a)

Sol:
```
int count = 0
for( i=0 ; i < n ; i++)
{
        if (a[i] = = k)
        {
            count++;
        }
}
if (count > n/2)
printf(" More than ½ times");
```

11. Ans: (c)

Sol: $f(n) = 3T(n/3)+1$

From case2, Master method $T(n) = O(\log_3 n)$.

12. Ans: (d)

13. Ans: (d)

14. Ans: (a)

15. Ans: (b)

Sol: Reduction takes $O(n^2)$

Solving problem takes $O(n^2+n^3) = O(n^3)$.

16. Ans: (d)

Sol: 1 – level – root 1

2 – level 2

3 – level 3

:

n – level .....n

Total number of nodes = 1+2+...+n

$$= \frac{n(n+1)}{2} = O(n^2)$$

17. Ans: (d)

Sol: (a) $n^{4/3} \ngeq c.2^{2^n}$ for any n

(b) $2^{2^n} \ngeq 2^{n^2}$ for any $n \geq 3$

(c) $n^{4/3} < 2^n < n! < 2^{2^n} \nless 2^{n^2}$

(d) $n! \leq c.\ 2^{n^2}$ true

18. Ans: (a)

Sol: $i \rightarrow$ runs n+1 times

$j \rightarrow$ runs $n\left(1+\frac{1}{2}+\frac{1}{3}+...+\frac{1}{n}\right)$ times

$\Rightarrow O(n \log n)$

19. Ans : (d)

Sol: For each value of i, the inner for loop running $\sqrt{n}$ times, So total Running Time is $O(n\sqrt{n})$.

20. Ans: (a)

Sol: (I) $(n+3)^3 = O(n^3)$

($\because$ It is a Polynomial of degree 3)

(II) $3^{n+1} = 3^n.\ 3$

$= O(3^n)$

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21. **Ans: (a)**

Sol: Recurrence Equation is $T(n) = T(\sqrt{n}) + 1$

22. **Ans: (c)**

23. **Ans: (c)**

24. **Ans: (d)**

Sol: $O(N^{2.5})$ means $N^{2.5}$ is the Upper Bound

$\therefore$ The Algorithm A takes less than or equal to $N^{2.5}$ time but not more.

25. **Ans: (a)**

Sol: $f(n) = 2^n$, then $2^n \le c.n!$

Because $2^n \not\le c.\ n^2$, $2^n \not\le c.\ n$, $2^n \not\le c.\ n^3$

26. **Ans: (c)**

Sol: (a) $n^n \ne O(2^n)$

(b) $f(n) \le c.\ g(n)$ then $g(n) \not\le c.\ f(n)$

(c) $f(n) \le c.\ g(n)$ then $\frac{1}{c} f(n) \ge g(n)$

$= g(n) = \Omega(f(n))$ (True)

(d) $2^{f(n)} \le c.\ 2^{g(n)}$ but $c.2^{f(n)} \not\ge 2^{g(n)}$

27. **Ans: (d)**

Sol: sin x lies in [–1, 1]

g(n) value depends on sin x

(a), (b) and (c) are not true.

28. **Ans: (a)**

Sol: $f(n) = \log\log n \le c.\sqrt{\log n}$, $\forall\ n \ge n_0$

$h(n) = n^2 \log n \ge c.\sqrt{\log n}$, $\forall\ n \ge n_0$

(b), (c) and (d) are false

29. **Ans: (d)**

Sol: (a), (b) and (c) are correct but $n^n \not\le c.\ 2^n$

So option (d) is not correct.

30. **Ans: (b)**

Sol: $T(n) = \log_2 1 + \log_2 2 + \log_2 3 + \log_2 4 + \ldots + \log_2 n$

and

$$c_1\, n \log n \le \sum_{j=1}^{n} \log_2 j \le c_2 \sum_{j=1}^{n} \log_2 j, \forall\ n \ge n$$

$$T(n) = \Theta(n \log_2 n)$$

31. **Ans: (c)**

Sol: for(i = 1; i ≤ n; i++) → n + 1 times

for(j = 1; j ≤ i * i; j++) → $1^2+2^2+\ldots+n^2$ times

{

if(j mod i = = 0) → $1^2+2^2+\ldots+n^2$ times

for(k =1; k ≤ j; k++) → n^5 times

x = x + 10;

}

$$T(n) = (1^2 + 2^2 + \ldots + n^2)\,(n^2)$$

$$= \frac{n(n+1)(2n+1)}{6} n^2 = O(n^5)$$

32. **Ans: (a)**

Sol: $\sum_{i=1}^{n} k^i = k + k^2 + k^3 + \ldots k^n = \frac{k^{n+1} - 1}{k - 1}$

$= \Theta(k^n)$

33. **Ans: (b)**

Sol: I. $n^3 \log n \ge 1.\ n^3\ \forall\ n \ge 2$

II. $\underset{n\to\infty}{\text{Lt}} \frac{n^2}{n} = \infty \Rightarrow n^2 = \omega(n)$

III. $2^{n+1} \not\le c.\ 2^n$ (*)

IV. $\underset{n\to\infty}{\text{Lt}} \frac{f(n)}{g(n)} = 0 \Rightarrow g(n) \ge c.f(n)\ \forall\ n$

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34. Ans: (a)

Sol: From the Big(O) definition.

35. Ans: (d)

	$\sqrt{\log n}$	$\sqrt{n}$	n	$2^{\sqrt{\log n}}$	2^{2^n}
n = 1	0	1	1	1	4
n = 2	1	1.414	2	2	$2^4 = 16$
$n = 2^2$	1.414	2	4	$2^{1.414}$	2^{16}
$n = 2^3$	1.414	3	8	$2^{1.44}$	2^{256}
$n = 2^4$	2	4	16	2^2	–
$n = 2^5$	–	–	–	–	–
$n = 2^6$	–	–	–	–	–

$\sqrt{\log n} < \sqrt{n} < 2^{\sqrt{\log n}} < n < 2^{2^n}$

$P < S < R < Q < T$

36. Ans: (d)

Sol:

	logn	$\sqrt{n}$	n	n^2	$\sqrt{2^n}$	$2^{\sqrt{n}}$
n=1	0	1	1	1	1.414	2
n=2	1	1.414	2	4	2	2.66
$n=2^2$	2	2	4	16	4	4
$n=2^3$	3	2.828	8	64	16	7.1008
$n=2^4$	4	4	16	256	256	16
$n=2^5$	5	5.656	32	124	65536	50
$n=2^6$	6	8	65	4096	4294967296	1024
$n=2^8$	8	16	256	65536	-	65536

Faster than n^2, slower than $\sqrt{2^n}$

37. Ans: (c)

Sol: (a) $\rightarrow n! \neq O(2^n)$ because $n! \leq c.\ n^n$

(b) $\rightarrow 2^n \neq O(n^2)$

(c) $\rightarrow \log n! \leq c.\ n \log n$

(d) $\rightarrow n^2 \neq O(n + \log n)$

38. Ans: (a)

Sol: **Option a:** $n^3 2^n + 6n^2 3^n \nleq c.\ n^3 2^n$

$\therefore$ a is false

Option b: $33n^3 + 4n^2 \geq c.\ n^2$

$\Rightarrow 33n^3 + 4n^2 = \Omega(n^2)$

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Option c:

$$\sum_{i=0}^{n} i^2 = 1^2 + 2^2 + \ldots + n^2 = \frac{n(n+1)(2n+1)}{6} \le c.n^3$$

$$= \Theta(n^3)$$

Option d:

$$n! = n(n-1)(n-2)\ldots.3.2.1 \le n! = O(n^n)$$

39. **Ans: (c)**

Sol: I. $\log^x n \le c.\, n^Y, \forall\, n \ge n_0$ and $x > 0, y > 0$ true Since $\log n < n$

II. $4\log_2 n \le 1.n^2\ \forall\ n \ge 1$ True

III. $4.\, n^{3/2} \ngeq c.\, n^2\ \forall\ n \ge 4$ False

IV. $10n \log n \le 11n \log n\ \forall\ n \ge 2$ True

40. **Ans: (b)**

Sol: $\sum_{K=1}^{n} O(n) \le \sum_{K=1}^{n} Cn$, where C is constant

$$\le C \sum_{K=1}^{n} n$$

$$\le C.n^2\ \forall\ n \ge 1$$

From the Big oh Notation

$$\sum_{K=1}^{n} O(n) = O(n^2)$$

41. **Ans: (c)**

Sol: It runs until the difference between X and Y is zero When the difference is zero X is the GCD of X and Y.

42. **Ans: (d)**

Sol: (a) $\Rightarrow \log f(n)$ is $O(\log(g(n)))$ because $f(n)$ is $O(g(n))$, $\log f(n) \le C.\log(g(n))\ \forall n$

(b) $\Rightarrow 2^{f(n)}$ is $O(2^{g(n)})$

$\Rightarrow 2^{f(n)} \le C.2^{g(n)}$ because

$f(n) \le C.g(n), \forall\ n \ge n_0$

(c) $\Rightarrow (n+1)^5$ is $O(n^5)$

$\Rightarrow (n+1)^5 \le C.n^5$

$(n+1)^5 \le 10.\, n^5$ for $n \ge 1$

(a), (b) and (c) are true

43. **Ans: (c)**

Sol: for i = 1 to n–runs n times

for i = 1 to i^2–runs n^2 times

if (j mod i = = 0) – n^2 times

for k = 1 to j Approximately n^4 times

44. **Ans : (a)**

Sol: $T_1(N) + T_2(N) = O(f(n))$ because

$T_1(N) \le C_1\, f(n)$ and $T_2(N) \le C_2 f(n)$

45. **Ans: (a)**

Sol: Consider an execution of Insertion sort on array 'A'. In the outer loop there is O(n) work. Each iteration of inner loop fixed exactly one inversion, when algorithm terminates no inversion left out. So it takes O(n + I).

46. **Ans: (c)**

Sol: Suppose that the median is A[i], Since array is sorted, it is greater than exactly i–1 values in an array A and it is also greater than exactly $j = \left[\frac{n}{2}\right] - (i-1)$ elements in B.

It takes constant time to check if $B[j] \le A[i] \le B[j+1]$. If A[i] is not median then depending on whether A[i] is greater (or) less than B[j] and B[j + 1]. We can use Binary search for A[i] in O(log n) time.

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Chapter 2 Divide and Conquer

01. Arrange the following recurrence relations in the increasing order of their order of growth i.e. ignore constants; concentrate only on higher order terms.

i. $T_2(n) = 2T(n/2) + 1$

ii. $T_3(n) = 3T(n/3) + 1$

iii. $T_5(n) = 5T(n/5) + 1$

(a) $T_2 < T_3 < T_5$ (b) $T_5 < T_3 < T_2$

(c) $T_2 = T_3 = T_5$ (d) None of the above

02. If 'k' is a positive constant, then the following Divide & Conquer recurrence evaluates to

$T(n) = k, n = 1$

$= 3T(n/2) + kn, n > 1$

Assuming 'n' is a power of 2

(a) $T(n) = 3kn^2 - kn$

(b) $T(n) = 3kn^{\log_2 3} - 2kn$

(c) $T(n) = 3kn^{\log_2 3} - kn$

(d) $T(n) = 3k.n^2 - 2.k.n^{\log_2 3}$

03. In quick sort, for sorting 'n' elements, the $(n/4)^{th}$ smallest element is selected as pivot using an O(n) time algorithm. What is the worst case time complexity of the quick sort?

(a) $\Theta(n)$ (b) $\Theta(n \log n)$

(c) $\Theta(n^2)$ (d) $\Theta(n^2 \log n)$

04. Let T(n) be the function by T(1)=1,

$T(n) = 2T(n/2) + \sqrt{n}$ for $n \geq 2$.

Which of the following statements is ***true***?

(a) $T(n) = O(\sqrt{n})$

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

(c) $T(n) = O(\log n)$

(d) None of the above

05. The recurrence equation

$T(1) = 1$

$T(n) = 2T(n-1) + n, \quad n \geq 2$

Evaluates to

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

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

06. Suppose A is a sorted array and some of the elements are duplicates, what is the best upper bound to find out the number of elements that are equal to a given key 'k'.

(a) O(log n) (b) O(n)

(c) O(n logn) (d) None

07. The running time T(n), where 'n' is the input size of a recursive algorithm is given as follows.

$T(n) = c + T(n-1)$, if $n>1$

$= d$, if $n \leq 1$

The order of the algorithm is:

(a) n^2 (b) n

(c) n^3 (d) n^n

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08. The running time of an algorithm is given by
$T(n) = T(n-1)+T(n-2)-T(n-3)$, if $n > 3$
$= n$, otherwise.
The order is:
(a) n (b) log n
(c) n^n (d) n^2

09. The tightest lower bound on the number of comparisons, in the worst case, for comparison based sorting is the order of
(a) n (b) n^2 (c) n log n (d) $n \log^2 n$

10. The running time of the following algorithm
procedure A(n)
If n <= 2 return (1); else return ($A\lceil \sqrt{n} \rceil$);
is best described by
(a) O(n) (b) O(log n)
(c) O(log log n) (d) O(1)

11. $T(n) = T\left(\frac{n}{2}\right) + 2^n$
(a) O(n log n) (b) $O(n^2)$
(c) $O(2^n)$ (d) O(n)

12. Which of the following sorting methods is ***not stable***?
(a) Heap sort (b) Merge sort
(d) Insertion sort (d) Selection sort

13. The time complexity of an algorithm has been found to be in the following form of Recurrence
$T(n) = 4.T(n/2)+n^{2.5}, n > 1$
$= 1, \quad n = 1$
Then T(n) is
(a) $\Theta(n)$ (b) $\Theta(n^2 \log n)$
(c) $\Theta(n^2)$ (d) $\Theta\left(n^{\frac{10}{4}}\right)$

14. The solution to the recurrence
$T(2^k) = 3.T(2^{k-1})+1$ with $T(1) = 1$ is:
(a) O(k) (b) $O(3^k)$
(c) $O(3^{\log k})$ (d) $O(2^k)$

15. If given numbers are
12, 7, 15, 8, 19, 20, 17, 21, 5, 3
in _____ passes of quick sort element 5 will be in sorted position.

16. Let T(n) be a function defined by the recurrence
$T(n) = T(n/2) + \sqrt{n}$, for $n \geq 2$ and
$T(1) = 1$
Which of the following statements is *true*?
(a) $T(n) = \Theta(\log n)$
(b) $T(n) = \Theta(\sqrt{n})$
(c) $T(n) = \Theta(n)$
(d) $T(n) = \Theta(n \log n)$

17. $T(n)=2T(n/2) + n$ for $n > 1$
$T(1)=1$ then T(n) is
(a) O(n) (b) $O(n^2)$
(c) O(n log n) (d) None of these

18. If we are merging two sorted lists of sizes '50' and '40' into a sorted list of size 90, then in the worst case we requires the number of comparisons are _____.

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19. Give the correct matching for the following pairs:

List–I	List–II
(A) O(log n)	(P) Bubble sort
(B) O(n)	(Q) Insertion sort(best case)
(C) O(n log n)	(R) Binary search
(D) $O(n^2)$	(S) Merge sort

(a) A – R, B – P, C – Q, D – S
(b) A – R, B – Q, C – S, D – P
(c) A – P, B – R, C – S, D – Q
(d) A – R, B – S, C – R, D – Q

20. The solution to the recurrence equation
$T(2^k) = 3\,T(2^{k-1}) + 1$,
$T(1) = 1$ is:
(a) 2^k
(b) $(3^{k+1} - 1)/2$
(c) $3^{\log_2 k}$
(d) $2^{\log_3 k}$

21. Let T(n) be a function defined by the recurrence $T(n) = 2T\left(\frac{n}{2}\right) + \sqrt{n}$ for $n \geq 2$ and $T(1) = 1$. Then which of following statement is **true**?
(a) $T(n) = \Theta(\log 2^n)$
(b) $T(n) = \Theta(\sqrt{n})$
(c) $T(n) = \Theta(n)$
(d) $T(n) = \Theta(n(\log 2^n))$

22. The solution to the following recurrence if
$T(n) = 2\,T\left(\frac{n}{2}\right) + 2$, $n > 2$
$= 1$, $n = 2$
(a) O(n)
(b) $O(\log 2^n)$
(c) $O(\log \log_2 n)$
(d) O(1)

23. If one uses straight Two-way Merge Sort algorithm to sort the following elements in ascending order 20, 47, 15, 8, 9, 4, 40, 30, 12, 17 then the order of these elements after the third pass of the algorithm is:
(a) 4, 8, 9, 12, 15, 17, 20, 30, 40, 47
(b) 4, 8, 9, 12, 17, 15, 30, 20, 47, 40
(c) 4, 8, 9, 15, 20, 30, 40, 47, 17, 12
(d) None of these.

24. Given the following recurrence relation:
$T(n) = 2T(n/4) + \sqrt{n}$, $n > 1$
$= 1$, $n = 1$
T(n) is in the order of
(a) $\sqrt{n}$
(b) n
(c) $\sqrt{n}$ .log n
(d) n log n

25. If T(0) = T(1) = 1 for $n \geq 2$, which of the following **cannot** be bounded by a polynomial function ?
(a) $T(n) = 3T(n/2) + n^2$
(b) $T(n) = 4T(n/2) + n$
(c) $T(n) = T(n-1) + n^2$
(d) $T(n) = 2T(n-1) + 1$

26. The number of comparisons that are necessary and sufficient for finding both the largest and smallest elements in a set of 'n' elements is
(a) (3n/2) – 2
(b) 2n – 2
(c) (3n/2) – 1
(d) None

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27. The order of the following Recurrence Relation is

$T(n) = C$ for $n < d$, $d \geq 1$, $C > 0$

$= 9T(n/3) + n^3 \log n$

(a) $\Theta(n^2 \log n)$ (b) $\Theta(n^3 \log n)$

(c) $\Theta(n^3 \log^2 n)$ (d) None of these

28. $T(n) = T(\sqrt{n}) + O(\log \log n)$

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

(c) $O((\log \log n)^2)$ (d) $O(n)$

29. If $T(n) = T(\lceil n/2 \rceil) + T(\lfloor n/2 \rfloor) + 2n$, then what is $\Theta(T(n))$?

(a) $\Theta(n)$ (b) $\Theta(\log n)$

(c) $\Theta(n^2)$ (d) $\Theta(n \log n)$

30. Consider the recurrence

$T(n) = 8\,T(n/2) + n^2, \quad n > 1$

$= 1 \quad , \quad n = 1$

Then $T(n)$ is

(a) $O(n^3)$ but not $O(n^2)$

(b) $O(n^2)$ but not $\Omega(n^2)$

(c) $O(n^3)$

(d) $O(n^2 \log n)$

31. The Divide and Conquer recurrence that would arise to multiply two big integers I and J represented with n-bits each is:

(a) $T(n) = 3\,T(n/2) + cn$

(b) $T(n) = 3\,T(n/2) + cn^2$

(c) $T(n) = 3\,T(n/2) + c$

(d) $T(n) = 3\,T(n/2) + c \log n$

32. If one uses Quick sort algorithm to sort the elements 5, 4, 3, 2, 5, 8, 9 in ascending order. What is the output after the 1st pass of the Quick sort algorithm?

1. Without modifying partition algorithm.
2. Modifying the statement in partition if(i<j) to if (i≤ j) respectively.

(a) 5,4,3,2,5,8,9 5,4,3,2,5,8,9

(b) 2,4,3,5,5,8,9 5,4,3,2,5,8,9

(c) 2,4,3,5,5,8,9 2,4,3,5,5,8,9

(d) 5,4,3,2,5,8,9 2,4,3,5,5,8,9

33. Given $T(n) = c$, if $n = 1$, c is a constant.

$= \sqrt{n} \cdot T(\sqrt{n}) + n, \; n > 1.$

Then which of the following is **true** ?

(a) $T(n) = \Theta(n \log n)$

(b) $T(n) = \Theta(n. \log \log n)$

(c) $T(n) = \Theta(n.\log^2 n)$

(d) $T(n) = \Theta(n)$

Statement for Question 34 is given below.

Consider the following algorithm, assume procedure 'A' & procedure 'B' take O(1) and O(n) unit of time respectively,

```
algorithm Test(n)
{    if (n = 1)then call A( )
     else
     {
          Test(n – 1);
          Call B(n);
     }
}
```


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34. The time complexity of the above algorithm 'O' notation is

(a) $O(n^2)$ (b) $O(n)$

(c) $O(\log n)$ (d) $O(2^n)$

35. The recurrence that would arise for the following program fragment would be

```
void test (int n)
{
    int i, j;
    if (n > 0)
    {
        for (i = 1; i <= n; ++i);
        j = i;
        test (n/2);
        test(n/2);
    }
}
```

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

(b) $T(n) = 2T(n/2) + c$

(c) $T(n) = 2T(n/2) + \log n$

(d) $T(n) = CT(n/2) + \log n$

Statement for Question 36 given below:

Let $f(n) = \sum_{i=1}^{n} 2^i$ be a given function of 'n'.

36. Which of the following represents the order of growth of the expression?

(a) $\Theta(2^n)$ (b) $\Theta(n^{n \log n})$

(c) $\Theta(2^n \log n)$ (d) $\Theta(n^2)$

37. Consider a set of 'n' elements in an array, which is sorted except for one-element that appears out of order. Which of the following sort the sequence in O(n) time ?

(a) Quick sort (b) Heap sort

(c) Merge sort (d) Bubble sort

38. The Best possible Complexity of Comparison based sorting algorithms in worst case is :

(a) $O(n\log n)$ (b) $O(n)$

(c) $O(n^2)$ (d) $O(n^n)$

39. The recurrence relation that arises in relation with the Complexity of binary Search is:

(a) $T(n) = T(n/2) + k$, k is a constant

(b) $T(n) = 2.T(n/2) + k$, k is a constant

(c) $T(n) = T(n/2) + \log n$

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

40. Which of the following Statements are ***true?***

I. As the number of entries in a hash table increases, the number of Collisions increases

II. Recursive programs are efficient

III. The worst case complexity for Quick sort is $O(n^2)$

IV. Binary Search using a linear linked list is efficient.

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

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

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41. Quick Sort run's on two inputs shown below to sort in ascending order

(i) 1,2,3, ...n

(ii) n, n–1, n–2, ...2,1

Let C1 and C2 be the number of Comparisons made for the input (i) and (ii) respectively. Then,

(a) C1 < C2

(b) C1 > C2

(c) C1 = C2

(d) We cannot say anything for arbitrary n.

Data for Q42 and Q43 are given below. Solve the problems and choose correct answer.

Consider the recursive algorithm given below:

```
Procedure bubblesort (n);
var i, j : index; temp: item;
begin
    temp : = A[i];
    A[i] : = A[i + 1]; then
begin
    temp : = A[i];
    A[i]: = A[i + 1];
    A[i + 1] : = temp;
end;
    bubblesort (n–1);
end
```

Let a_n be the number of times the 'if … then …..' statement gets executed when the algorithm is run with value n.

42. Set up the recurrence relation by defining a_n in terms of a_{n-1}.

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

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

(c) $a_n = na_{n-1} + 1$

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

43. Solve for above "a_n"

(a) $\frac{n(n+1)}{2}$

(b) n (n + 1) (n+ 2)/ 16

(c) $\frac{n^2(n-1)^2}{4}$

(d) n(n + 1) (n + 2) / 3

44. T(n) = 2T (n/2 + 17) + n

(a) $O(n^2)$

(b) O(n log n)

(c) O(log n)

(d) O(n)

45. Given the array 25, 57, 48, 38, 11, 90, 89, 29. What is the output after the first pass using partition of Quick Sort?

(a) 11, 25, 48, 38, 57, 90, 89, 29

(b) 11, 25, 29, 38, 48, 57, 89, 90.

(c) 11, 25, 48, 38, 90. 89, 57, 29

(d) 11, 25, 48, 38, 57, 90, 29, 89.

46. An array A[1…….n] is unimodal if it consists of an increasing sequence followed by a decreasing sequence, for

m = {1, 2, 3…n} such that

A[i] < A[i + 1] for all $1 \le i < m$ and

A[i] > A[i + 1] for all $m \le i < n$.

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What is the Time Complexity for finding maximum element of uni-model input of an array A[1.....n]?

(a) O(n)
(b) O(n log n)
(c) $O(n^2)$
(d) O(log n)

47. Which of the following represents the best case analysis of Quick sort algorithm?

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

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

(c) $T(n) = T(n-1) + O(n)$

(d) $T(n) = T(n-1) + O(1)$

48. How many number of multiplications are required to Compute a^{29} using Divide and Conquer approach?

(a) 28
(b) 7
(c) 10
(d) 12

49. Consider the following statements

I. $f(n) = O(f(n)^2)$

II. $f(n) + O(f(n)) = O(f(n))$

Which of the following is **valid**?

(a) **I** – Always True, **II** – Sometimes True
(b) **I , II** – Always True
(c) **I** – Sometimes True, **II** – Always True
(d) **I, II** – Sometimes True

01. Ans: (c)

Sol: All are in the

So T(n) = O(

02. Ans: (b)

Sol: Use back su

03. Ans: (b)

Sol: If it is wors

of quick so

04. Ans: (b)

Sol: T(n) = 2 T

a = 2, b =

$a > b^k$

∴ O(n lo

= Θ(n

= O(n

05. Ans: (a)

Sol: T(2) = 2

= 2

= 4

Putting

Option

Option

Option

Option

So, **op**

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Solutions

01. Ans: (c)

Sol: All are in the form $T(n) = aT\lceil n/a \rceil + O(c)$, So $T(n) \approx O(n)$.

02. Ans: (b)

Sol: Use back substitution.

03. Ans: (b)

Sol: If it is worst case behaviour of average case of quick sort.

04. Ans: (b)

Sol: $T(n) = 2\,T(n/2) + \sqrt{2}$

$a = 2,\ b = 2,\ k = ½$

$a > b^k$

$\therefore O(n \log_b a)$

$= \Theta(n \log_2 2)$

$= O(n)$

05. Ans: (a)

Sol: $T(2) = 2T(1) + 2$

$= 2(1) + 2$

$= 4$

Putting $n = 2$ in Options

Option a: $2^{2+1} - 2 - 2 = 4$

Option b: $2^2 - 2 = 2$

Option c: $2^{2+1} - 2^2 - 2 = 2$

Option d: $2^2 + 2 = 6$

So, **option a** is correct.

06. Ans:(b)

Sol: First Binary search can be used to find out the key 'k' and then binary search to search for the boundaries of the elements 'k'.

07. Ans: (b)

Sol: By recursively applying the relation we finally arrived at

$T(n-1) = c(n-1) + T(1) = c(n-1) + d$

So, order is n.

08. Ans: (a)

Sol: Let us find what is T(4),T(5),T(6).

$T(4) = T(3) + T(2) - T(1) = 3+2-1=4$

$T(5) = T(4) + T(3) - T(2) = 4+3-2=5$

$T(6) = T(5) + T(4) - T(3) = 5+4-3=6$

By induction it can be proved that $T(n) = n$.

Hence order is n.

09. Ans: (c)

Sol: Comparison based sortings are selection sort, Bubble sort etc.

10. Ans: (c)

Sol: Recurrence equation

$T(n) = T(\sqrt{n}) + c$

$T = T\left(\sqrt{\sqrt{n}} + c\right) + c = T(n^{(1/2)^2}) + 2c$

$T(n) = T(n^{(1/2)^k}) + kc$

Here $n^{(1/2)^k}$

$\therefore\ a\dfrac{1}{2^k} = \log_n 2$

$\therefore\ 2^k = \log_2 n$

$\therefore\ k = \log_2 \log_2 n$

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$\Rightarrow T(n) = T(2) + (\log_2 \log_2 n)c$

$= O(1+(\log_2 \log_2 n)c)$

$= O(\log_2 \log_2 n)$

11. Ans: (c)

Sol: By using Case(3) of Master Theorem.

12. Ans: (a)

Sol: Heap sort is not stable sort.

It does not preserve the order of the same elements.

13. Ans: (d)

Sol: $T(n) = 4.T(n/2)+n^{2.5}$

$a = 4, b = 2, f(n) = n^{2.5}$

$n^{\log_2 4} = n^2 < n^{2.5}$

$\Rightarrow$ From case3 $T(n) = \Theta(n^{2.5})$

14. Ans: (b)

Sol: $T(2^k) = 3.T(2^{k-1})+1$

Assume $n = 2^k$

$T(n) = 3.T(n/2) + 1$

$= 3[3T(n/4)+1]+1$

$= 3^2T(n/2^2) + 3 + 1$

$= 3^k T(n/2^k) + 3^{k-1} + \ldots + 3 + 1$

$= 1 + 3 + 3^2 + \ldots + 3^k = \dfrac{3^{k+1}-1}{2} \le 3.3^k$

$\forall k \ge 1$

$= O(3^k)$

15. Ans: 2

Sol: Pass – 1 12, 7, 15, 8, 19, 20, 17, 21, 5, 3

↑ i j

Pivot

12, 7 3 8 5 20 17 21 19 15

j

Pass – 2 5, 7, 3, 8, 12, 20, 17, 21, 19, 15

↑

Pivot

16. Ans: (b)

17. Ans: (c)

Sol: $T(n) = 2T\left(\dfrac{n}{2}\right) + O(n)$

By using Master Theorem, a=2, b=2, Case (b),

So $T(n) = O\left(n^{\log_2 2}\right) = O(n \log n)$.

18. Ans: 89

Sol: Total number of Comparisons

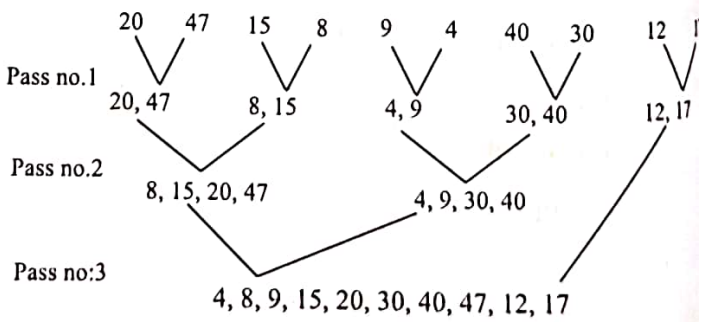
$= m + n - 1 = 89$

19. Ans: (b) **20. Ans: (b)**

21. Ans: (c) **22. Ans: (a)**

23. Ans: (d)

Sol: 4, 8, 9, 15, 20, 30, 40, 47, 12, 17



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24. Ans: (c)

Sol: $a = 2, b = 4, f(n) = \sqrt{n}$

$f(n) = n^{\log_b^a} = n^{\log_4^2} = \sqrt{n}$

from case 2 of Master Method

$T(n) = \Theta\left(n^{\log_b^a} \log n\right)$

$= \Theta\left(\sqrt{n} \log n\right)$

25. Ans: (d)

Sol: (a), (b) and (c) are bounded by polynomial function n^2 but (d) is bounded by exponential

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

$= 2[2T(n-2) + 1] + 1$

$= 2^2 T(n-2) + 2 + 1$

$= 2^3 T(n-3) + 2^2 + 2 + 1$

$= 2^{n-1} T(1) + 2^{n-2} + \ldots + 2 + 1$

$= 1 + 2 + 2^2 + \ldots + 2^{n-1} = 2^n - 1$

26. Ans: (a)

Sol: Straight forward Max. and Min. requires 2n–2 comparisons Recursive Max. and Min. using Divide and Conquer method requires (3n/2) – 2 comparisons.

27. Ans: (b)

Sol: $a = 9, b = 3, f(n) = n^3 \log n$ from case 3 of Master method.

$T(n) = \Theta(f(n))$

$= \Theta(n^3 \log n)$

28. Ans: (c)

Sol: Let $m = \log_2 n$

$S(m) = S\left(\frac{m}{2}\right) + O(\log_2 m)$

By Case(2) of Master Theorem

$T(n) = O((\log \log n)^2)$.

29. Ans: (d)

Sol: Assume $n = 2^k$ then $T(n) = 2T\left(\frac{n}{2}\right) + 2n$

$a = 2, b = 2, f(n) = 2n$ from case 2 of Master method

$T(n) = \Theta\left(n^{\log_b a} \log n\right)$

$= \Theta(n \log n)$

30. Ans: (c)

Sol: $a = 8, b = 2, f(n) = n^2$

from case 1 of Master Method

$T(n) = O\left(n^{\log_b^a}\right) = O(n^3)$

31. Ans: (a)

Sol: Divide integer I into two $\frac{n}{2}$ bit numbers, say ab.

Divide integer J into $\frac{n}{2}$ bit numbers, say cd.

```
        a   b
    *   c   d
  ---------------
        ad      bd
  ca    cb
  ---------------
  ca (ad+cb) bd
```


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It takes multiplications of size $\frac{n}{2}$, 3 shifts and 3 additions/ subtraction operations.

Now reduce number of multiplication by setwriting ad+cb as

$ad + cb = (a + b)(c + d) - ac - bd$

4 multiplications reduced to 3 multiplications.

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

cn is the time needed for the additions and subtractions.

32. Ans: (c)

Sol: Input: 5, 4, 3, 2, 5, 8, 9

1. Without modifying partition algorithm

Ist Pass 5, 4, 3, 2, 5, 8, 9
↑ j i
pivot

2. Modify the statement in partition if(i < j) to if(i ≤ j) then

5, 4, 3, 2, 5, 8, 9 → 2, 4, 3, 5, 5, 8, 9, →
↑ j i
after Ist pass
pivot

33. Ans: (b)

Sol: $T(n) = \sqrt{n}\,T(\sqrt{n}) + n$

Assume $m = \log n \Rightarrow n = 2^m$

$$T(2^m) = 2^{\frac{m}{2}} T\left(2^{\frac{m}{2}}\right) + 2^m$$

Assume $S(m) = T(2^m)$

$$S(m) = 2^{\frac{m}{2}} S\left(\frac{m}{2}\right) + 2^m$$

$a = 2^{\frac{m}{2}}, b = 2, f(m) = 2^m$

$S(m) = \Theta(2^m \log m)$

$T(n) = \Theta(n \log\log n)$

34. Ans: (a)

Sol: $T(n) = \begin{cases} A(\ ), & \text{if } n = 1 \\ T(n-1) + B(\ ), & \text{otherwise} \end{cases}$

$A(\ ) \to 1$

$B(\ ) \to n$

$T(n) = \begin{cases} 1, & \text{if } n = 1 \\ T(n-1) + cn, & \text{otherwise} \end{cases}$

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

$= T(n-2) + cn - 1 + n$

$= c + c2 + \ldots + c(n-1) + cn$

$= \frac{c.n(n+1)}{2} = O(n^2)$

35. Ans: (a)

Sol: $T(n) = 2T\left(\frac{n}{2}\right) + an$

2 test(n/2) for loop

36. Ans: (a)

Sol: $f(n) = \sum_{i=1}^{n} 2^i = 2 + 2^2 + 2^3 + \ldots + 2^n$

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

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

$= \Theta(2^n)$

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37. **Ans: (d)**

Sol: Quick Sort, Heap Sort, Merge Sort takes atleast $\Theta(n \log n)$ for any input order.

$\therefore$ Bubble Sort takes $O(n)$ time

38. **Ans: (a)**

Sol: Time complexities of comparison based, sorting Algorithms

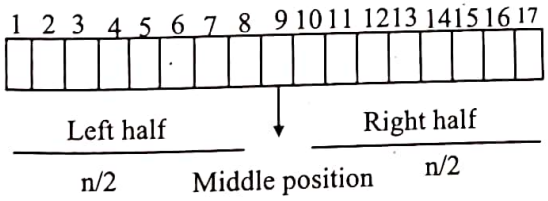
	Best case	Average case	Worst case
Bubble sort	$O(n^2)$	$O(n^2)$	$O(n^2)$
Selection sort	$O(n^2)$	$O(n^2)$	$O(n^2)$
Insertion sort	$O(n)$	$O(n^2)$	$O(n^2)$
Merge sort	O(nlogn)	O(nlogn)	O(nlogn)
Quick sort	$O(n^2)$	O(nlogn)	$O(n^2)$
Heap sort	O(nlogn)	O(nlogn)	O(nlogn)

$\therefore O(n \log n)$ time one can sort the elements.

39. **Ans: (a)**

Sol: $T(n) = T(n/2) + k$, k is a constant

The input data is in sorted order, not for searching it considers only either left half or right half from the middle position.



Only one half will be considered for searching

$\therefore T(n) = T(n/2) + k$, k is constant time to search and return the result

40. **Ans: (d)**

Sol: I. As the number of entries increases in the hash table collision increases

II. Recursive programs are not efficient because it require more memory (stack).

III. Quick sort worst case complexity is $O(n^2)$ because the position of pivot element is either left end or right end.

IV. Binary search using linked list is not efficient because every time the searching pointer must be moved to the middle position.

41. **Ans: (c)**

Sol: (i) 1, 2, 3, ..., n

if '1' is pivot then there are 'n' comparisons if 'n' is pivot then 'n' comparisons

after partition, one element one side remaining 'n–1' elements are other side continues this process.

(ii) n, n–1, n–2, ..., 2, 1

if 'n' is pivot then n comparisons

if '1' is pivot then n – comparisons

after partitions use same reason for both inputs has same number of comparison.

42. **Ans: (d)**

Sol: 0 1 2.....n-1

Suppose $a_0, a_1, a_2 \ldots a_{n-1}$

Element at 0 position is compared with next n–1 element

Similarly next first position is compared with next n – 2 elements

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

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43. Ans: (a)

Sol: $a_n = a_{n-1} + n-1$

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

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

$a_n = 1 + 2 + 3 + \ldots\ldots + (n-2) + (n-1)$

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

44. Ans : (b)

Sol: $T(n) = 2.\ T(n/2) + n$

$a = 2, b = 2, f(n) = n$

From Master method case2 f(n) is $\Theta(n \log_2 2))$

$T(n) = \Theta(n \log n) = O(n \log n)$

45. Ans : (a)

Sol: Given input

25	57	48	38	11	90	89	29

Pivot

Exchange because 57>25 and 11<25

25	11	48	38	57	90	89	29

Pivot exchange

11	25	48	38	57	90	89	29

46. Ans: (d)

Sol: By using Divide and Conquer solution we can find maximum element with $O(\log_2 n)$ time.

47. Ans: (b)

Sol: In Best Case of Quick sort algorithm, the pivot element placed exactly in the middlemost position in O(n) time, So the recurrence equation is $T(n) = 2T\left(\frac{n}{2}\right) + O(n)$

48. Ans: (b)

Sol: $a^{29} = a.a^{28} = a(a^{14})^2 = a((a^7)^2)^2$

$= a((a(a.a^2)^2)^2)^2$

$\therefore$ There are total of 7 multiplications

49. Ans: (c)

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Chapter 3 Greedy Method

01. Consider a weighted complete graph G on the vertex set $\{v_1, v_2, \ldots, v_n\}$ such that the weight of the edge (v_i, v_j) is $2|i-j|$. The weight of a minimum spanning tree of G is:

(a) n–1 (b) 2n–2

(c) $\frac{n}{2}$ (d) n^2

02. What is the profit 'P' obtained for the following instance of fractional knapsack problem if the strategy is to be greedy on p_i/w_i ratio, with knapsack weight of 11 and also find out the fractions of items chosen denoted by the tuple (f1,f2,f3,f4,f5):

I	1	2	3	4	5
p_i	3	6	8	1	2
w_i	6	3	5	1	4

(a) 17, (1/3,1,1,1,1)

(b) 10.5,(0,1,1,1,1/8)

(c) 18,(1/6,1,1,1,1/4)

(d) 16, (1/3,1,1,1,0)

03. We use Huffman's algorithm to obtain an encoding of alphabet {a,b,c} with frequencies f_a, f_b, f_c .Which of the following codes cannot possibly be obtained (no matter what the frequencies are).

Code 1: {0, 10, 11}

Code 2: {0, 1, 00}

Code 3: {10, 01, 00}

(a) Only code 2

(b) Only code 2 & code 3

(c) Only code 1 & code 3

(d) None of these

04. The characters a to h have the set of frequencies based on the first 8 Fibonacci numbers as follows:

a:1, b:1, c:2, d:3, e:5, f:8, g:13, h:21

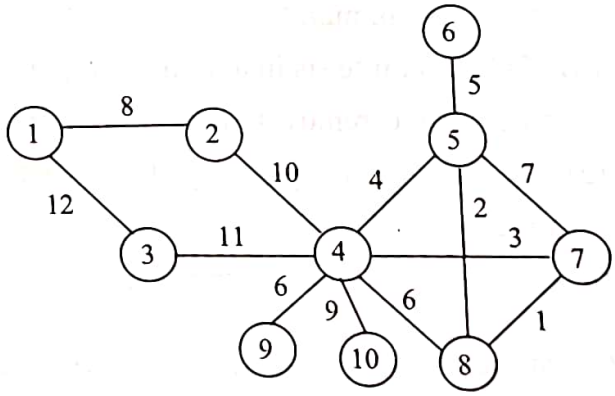
A Huffman code is used to represent the characters. What is the sequence of characters, corresponding to the following code?

110111100111010

(a) fdheg (b) ecgdf

(c) dchfg (d) fehdg

05. How many number of Minimum Cost Spanning Trees are possible for the following graph?



(a) 10^{10-2} (b) 10^{10}

(c) 1 (d) 10

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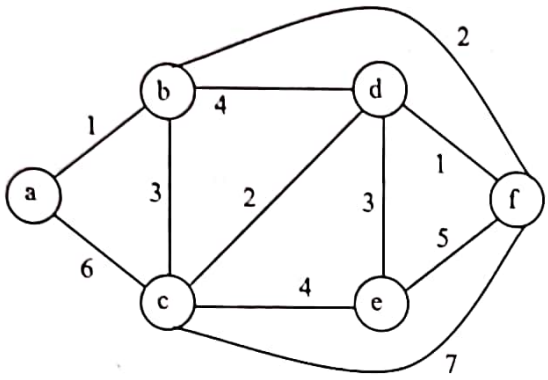
06.



Which of the following can be the sequence of edges added to the MST using Prim's algorithm?

(a) (c,d),(d,f),(f,b),(b,a),(d,e)
(b) (d,e),(d,f),(b,f),(a,b),(d,c)
(c) (d,e),(d,f),(d,c),(b,f),(a,b)
(d) (d,f),(d,e),(d,c),(b,f),(a,b)

07. Let G be an undirected connected graph with distinct edge weight. Let max 'e' be the edge with maximum weight and min 'e' be the edge with minimum weight. Which of the following statements is ***false***?

(a) Every minimum spanning tree of G must contain minimum 'e'.
(b) If maximum 'e' is in a minimum spanning tree, then its removal must disconnect G.
(c) No minimum spanning tree contains maximum 'e'.
(d) G has a unique minimum spanning tree.

08. Given the frequencies of the characters, what is the length of code for the character C?

Character	A	B	C	D	E	F	G	H	I
Frequency	2	2	3	3	5	6	10	20	40

(a) 6 (b) 5 (c) 4 (d) 3

09. An undirected Graph G has 'n' nodes. Its adjacency matrix is given by n × n square matrix, where

(i) Diagonal elements are 0's
(ii) Non-Diagonal elements are 1's

Which of the following is **true**?

(a) Graph 'G' has no minimum cost spanning tree
(b) Graph 'G' has unique minimum cost spanning tree with cost of n–1
(c) Graph 'G' has multiple distinct minimum cost spanning trees each of cost n–1
(d) Graph G has multiple spanning trees of different costs

10. Which algorithm design technique is the most efficient one for solving the problem of real knapsack.

(a) Enumerating strategy
(b) Divide & Conquer
(c) Greedy Strategy
(d) Backtracking

Statement for Linked Questions 11 & 12

Consider a language $L = \sum(a, b, c, d)$ with the respective frequencies of (0.3, 0.7, 0.6, 0.5).

11. The total number of bits required for encoding the following text:

(aaa bbbbbbb cccccc ddddd)

(a) 32 (b) 42 (c) 38 (d) 46

12. The average number of bits/message using Huffman coding is:

(a) 2 (b) 1.8 (c) 1.5 (d) 1.9

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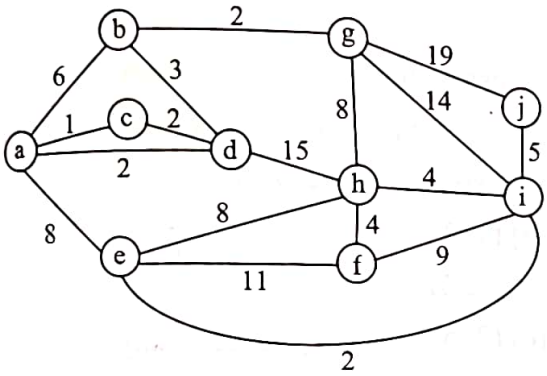
13. Find the Running Time of the fastest algorithm to calculate the shortest path between any two vertices of a graph where all edges have equal weights.

(a) $O(V \log_2 V + E)$ (b) $O(E + V)$

(c) $O(V \log_2 V + E)$ (d) $O(V+E) \log_2 V$

14. Consider the following Graph



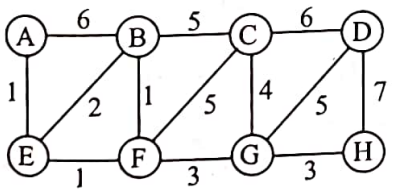
Let the weight of Minimum Spanning Tree in the.Graph is x. Then calculate the $10x + 20$ is _____.

15. In case of DIJKSTRA's algorithm (one of the implementations of link state algorithm), if 'n' is the number of nodes (excluding the source). How Many Number of nodes one Need to search in worst case through all the iterations?

(a) n^2 (b) $\frac{n(n+1)}{2}$

(c) n^3 (d) $n^2 \log n$

16. The cost of minimum spanning tree is _____.



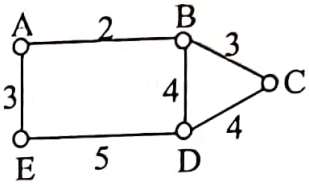
17. The total number of spanning trees and number of minimum cost spanning trees for the following graph are

(a) 12, 11

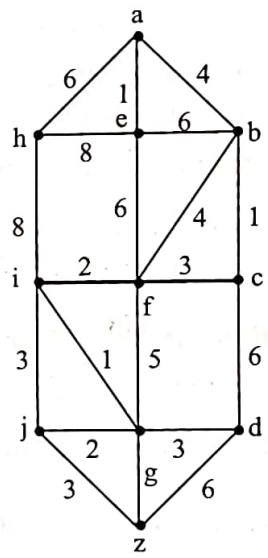
(b) 3, 12

(c) 2, 11

(d) None



18. Consider the following road map, where the length of the path is defined to be sum of the costs of the routes traversed. The length of the shortest path from a to i is:



(a) 14 (b) 10

(c) 9 (d) 12

Data for Q 19 is given below.

Consider the following set of messages ($m_1 - m_6$) with the following frequencies (0.12, 0.03, 0.07, 0.34, 0.20, 0.24)

Using Huffman coding, with the convention that, the left branch is labeled 0 and right branch 1, of the decode tree;

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19. What is the text in terms of messages ($m_1 - m_6$) corresponding to the binary stream 10101011100101
(a) $m_6m_6m_6m_4m_6m_4$
(b) $m_6m_6m_4m_6m_2m_1$
(c) $m_6m_6m_6m_4m_6m_2$
(d) $m_6m_6m_6m_4m_6m_3$

20. Consider the following coin changing problem:
Suppose that we want to make change for an amount A using fewest number of coins of given denominations. For example denominations given are 1, 5, and 10, if we want to make change for A = 18, it could be one 10, one 5 and three 1's.If the above problem is solved using greedy method, then the timing complexity of it would be
(a) O(n) (b) $O(n^2)$
(c) $O(2^n)$ (d) None

Data for Question 21 is given below:

Consider two one – dimensional arrays A_1 & A_2 with n/2 – elements each in sorted order.

21. The timing complexity to find the number of record movements involved is:
(a) O(n) (b) $O(n^2)$
(c) O(log n) (d) O(n log n)

Statement for Linked answer Q22 and Q23 is given below.

Consider the following instance of continuous Knapsack problem:

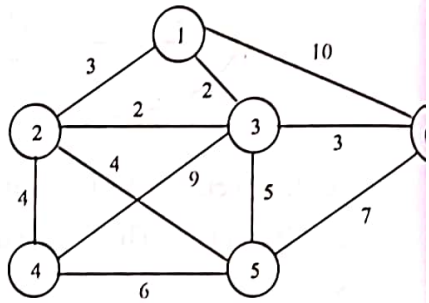
i:	1	2	3	4	5	6	7	8
P_i:	90	61	50	33	29	23	15	13
W_i:	33	30	25	17	15	12	10	9

M = 92;

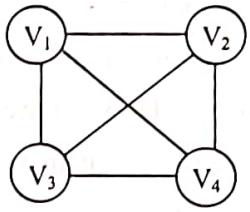
22. Solving above instance using Greedy Method will include all the objects except:
(a) (1, 2, 3, 4) (b) (5, 6, 7, 8)
(c) (2, 4, 6, 8) (d) (1, 3, 5, 7)

23. The profit obtained in the above solution is approximately:
(a) 209 (b) 215
(c) 234 (d) 80

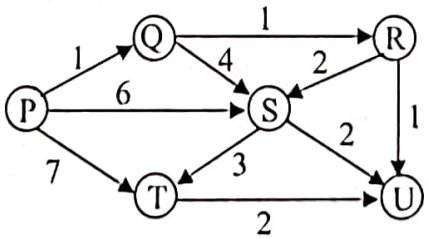
24. Consider the graph given below:
Using Kruskal's method to find minimum cost spanning tree, will not include the edge
(a) (1, 3)
(b) (2, 3)
(c) (2, 5)
(d) (1, 2)



25. How many spanning trees are possible?
(a) 10
(b) 12
(c) 14
(d) 16



26. Shortest path algorithm on the following edge-weighted directed graph with vertex P as the source.



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In what order do the nodes gets included into the set of vertices for which the shortest path distances are finalized?

(a) P, Q, R, S, T, U
(b) P, Q, R, U, S, T
(c) P, Q, R, U, T, S
(d) P, Q, T, R, U, S

27. The optimal solution generated by the job sequencing with deadlines with n = 7, $(P_1, P_2, P_3, \ldots P_7) = (3, 5, 20, 18, 1, 6, 30)$ and $(d_1, d_2, d_3, \ldots d_7) = (1, 3, 4, 3, 2, 1, 2)$ is.

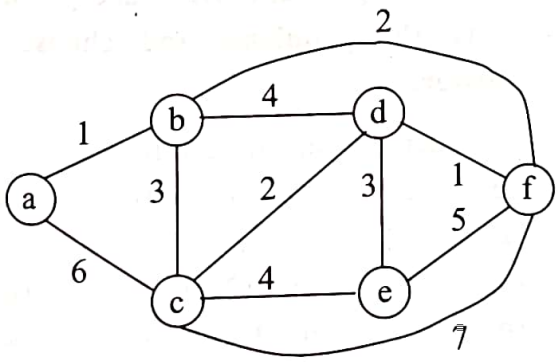
(a) 72
(b) 80
(c) 74
(d) 85

28. The minimum number of record movements required to merge five files
A(with 10 records), B(with 20 records), C(with 15 records), D(with 5 records) and E(with 25 records) is:

(a) 165
(b) 90
(c) 75
(d) 65

Common Data for Q29, Q30 & Q31 is given below.

Consider the following graph:



29. The spanning tree will have a minimum cost of

(a) 13
(b) 10
(c) 15
(d) 9

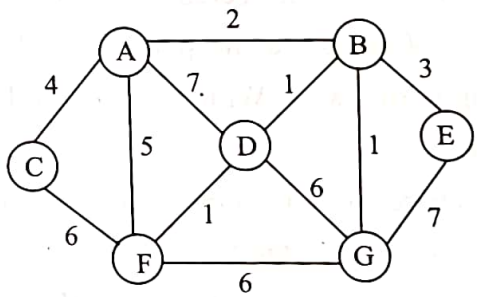
30. By applying Dijktsra's single source shortest path algorithm, the spanning tree will have a cost of (assume source as 'a').

(a) 10
(b) 11
(c) 12
(d) 13

31. Which one of the following cannot be the sequence of edges added, in that order, to a minimum spanning tree using Kruskal's strategy?

(a) (a – b), (d – f), (b – f), (d – c), (d – e)
(b) (a – b), (d – f), (d – c), (b – f), (d – e)
(c) (d – f), (a – b), (d – c), (b – f), (d – e)
(d) (d – f), (a – b), (b – f), (d – e), (d – c)

32. Consider the graph given below:



While computing the minimum cost spanning tree using Kruskal's method : Which of the following edges may be present in the **tree**?

(a) (F,D) (A,B) (B,E) (A,C) (A,F) (A,D)
(b) (F,D) (A,B) (A,D) (C,E) (A,F) (A,D)
(c) (F,D) (A,B) (B,E) (A,C) (A,F) (B,E)
(d) (F,D) (A,B) (B,E) (D,G) (A,F) (A,E)

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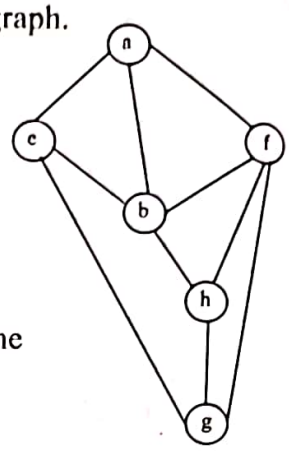
33. Consider a Knapsack instance for n = 3, $(w_1, w_2, w_3) = (3, 5, 6)$ and $(p_1, p_2, p_3) = (1, 4, 5)$ and m = 10.
The optimal solution is
(a) (0, 4/5, 1)
(b) (1/3, 0, 1)
(c) (1, 1, 3/5)
(d) None

34. A pharmacist has 'w' pills and 'n' empty bottles. Let {P1, P2, ... Pn} denote the number of pills each bottle can hold. It is required to determine the fewest number of bottles needed to store all the pills.
Which of the following design technique will find an optimal solution efficiently?
(a) Divide & Conquer
(b) Greedy Method
(c) Dynamic Programming
(d) Backtracking

35. Let 'w' be the minimum weight among all the edges in an undirected connected weighted graph. Let 'k' be the particular edge with a weight of 'w'. Which of the following is ***false***?
(a) There is a minimum spanning tree containing edge 'k'.
(b) If 'k' is not included in the minimum spanning tree, then there may exist a cycle including edge 'k'.
(c) Every minimum spanning tree has edge of weight 'w'.
(d) The edge 'k' is present in each & every spanning tree.

36. Consider the following graph.
1. a b e g h f
2. a b f h g e
3. a b f e h g
4. a f g h b e
Among the above sequences which are the depth first traversals of the given graph.



(a) 1, 2, 4 only
(b) 2, 3 & 4 only
(c) 1, 4 only
(d) 1, 3, 4 only

37. An undirected graph G has 'n' nodes. Its adjacency matrix is given by an n × n square matrix whose
(i) Diagonal elements are 0's.
(ii) Non-diagonal elements are 1's.
Which one of the following is ***true***?
(a) Graph G has no minimum spanning tree (MST).
(b) Graph G has unique MST's each of cost n – 1.
(c) Graph G has multiple distinct MST's each of cost n – 1.
(d) Graph G has multiple spanning trees of different costs.

Data for Q.38 and Q.39 are given below. Solve the problems and choose correct answer.

Consider a waited undirected graph with vertex set V = $\{n_1, n_2, n_3, n_4, n_5, n_6\}$ and edge set E = $\{(n_1, n_2, 2), (n_1, n_3, 8), (n_1, n_6, 3), (n_2, n_4, 4), (n_2, n_5, 12), (n_3, n_4, 7), (n_4, n_5, 9) (n_4, n_6, 4)\}$. The Third value in each tuple represents the weight of the edge specified in the tuple.

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38. List the edges of a minimum spanning tree of the graph.

(a) $\{(n_1, n_2, 2), (n_1, n_6, 3), (n_2, n_4, 4), (n_3, n_4, 7), (n_4, n_6, 4)\}$

(b) $\{(n_1, n_2, 2), (n_1, n_6, 3), (n_2, n_4, 4), (n_4, n_5, 9), (n_3, n_4, 7)\}$

(c) $\{(n_1, n_2, 2), (n_1, n_6, 3), (n_1, n_3, 8), (n_4, n_6, 4), (n_3, n_4, 7)\}$

(d) None

39. How many **distinct** minimum Spanning trees does this graph have?

(a) 1 (b) 2

(c) 34 (d) 2^{34}

40. Consider the statements below:

I. Let T be a spanning tree of a graph G = (V, E) and let V^1 be a subset of V. Let T^1 be a subgraph of 'T' induced by V^1 and G^1 be a subgraph of 'G' induced by V^1. If T^1 is connected, then T^1 is a minimum spanning tree of G^1.

II. All pairs shortest paths problem can be solved by using single source shortest path problem in a time of $O(n^3)$ where 'n' is the number of vertices.

III. The diameter of a tree T = (V, E) is the largest of all shortest-path distances in the tree. The diameter of a tree can be obtained by using Breadth First Search (BFS).

Which of the above statements are **true**?

(a) I only (b) I & II

(c) II & III (d) All are true

41. Single source shortest path problems can be implemented by Greedy method Using

(a) Red – black trees (b) Min heap

(c) AVL trees (d) None of these

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Solutions

01. Ans: (b)

Sol: When v_i is connected to v_{i+1}, the edge cost is 2, there will be (n-1), such edges with a cost of '2'.

Therefore total cost = 2(n–1)

= 2n–2

(or)

$$\sum_{j=1}^{n} 2|v_i - v_i - 1| = 2\sum_{i=1}^{n}|1| = 2|n-1| = 2n-2$$

02. Ans: (d)

Sol: We need to sort the items on profit to weight ratio.

03. Ans: (b)

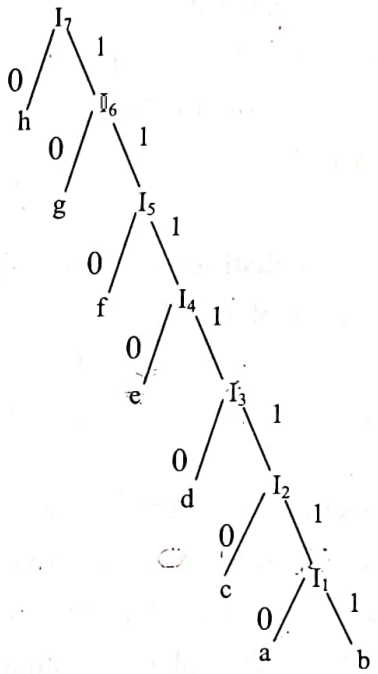
Sol: In code-2 and code-3 there are internal nodes which have one child, but Huffman tree is always full binary tree.

04. Ans: (a)

Sol:

a	b	c	d	e	f	g	h
(1)	(1)	(2)	(3)	(5)	(8)	(13)	(21)
c	d	e	f	g	h		
(2)	(3)	(5)	(3)	(8)	(21)		
d	I_2	e	f	g	h		
(3)	(4)	(3)	(8)	(13)	(21)		
e	I_3	f	g	h			
(5)	(7)	(8)	(13)	(21)			
f	I_4	g	h				
(8)	(12)	(13)	(21)				
g	I_5	h					
(13)	(20)	(21)					
h	I_6						
(21	33)						

Now: 110 11 11 0 0 1 1 1 0 1 0



05. Ans: (c)

Sol: We get only one Minimum Cost Spanning Tree, because the graph Contain all edge weights are distinct.

06. Ans: (a)

07. Ans: (c)

Sol: **Option a:** It is true because minimum Spanning tree contains minimum edge.

Option b: It is true because minimum Spanning tree is disconnected when max e is deleted.

Option c: It is false because MST may contain maximum edge.

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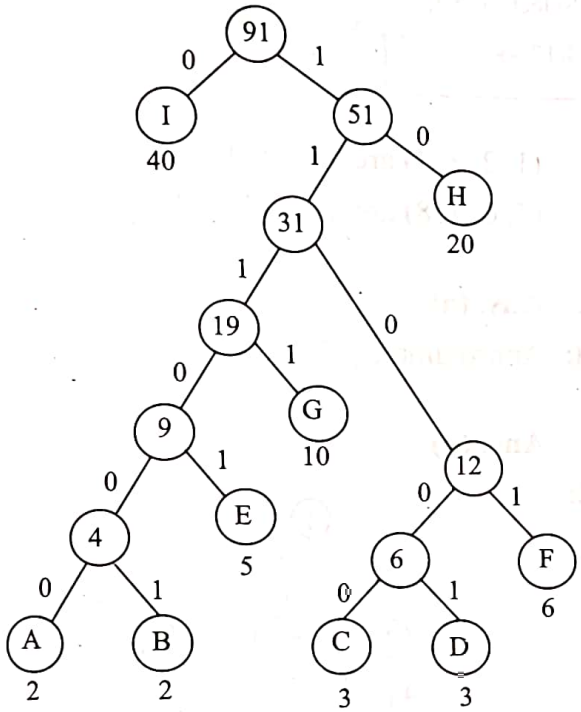
Option d: It is true because graph G has distinct edge weights.

08. Ans: (b)

Sol: Huffman Tree Construction



Code for C = 11000

Number of bits = 5

09. Ans: (c)

Sol: **Option a:** is false

Option b: is false

Option c: is true ⇒ It has n^{n-2} minimum spanning trees.

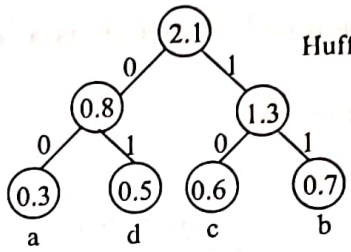
Option d: is false

10. Ans: (c)

Sol: Real Knapsack also called as fractional knapsack. To solve this Greedy Strategy is the best.

11. Ans: (b)

Sol:



Huffman tree

a = 00 – 2 bits

b = 11 – 2 bits

c = 10 – 2 bits

d = 01 – 2 bits

21 characters → 21 * 2 = 42 bits

12. Ans: (a)

Sol: Each character requires 2 bits

Average = 2

13. Ans: (b)

Sol: BFS is the algorithm to be used.

14. Ans: 330

Sol: x = 31

$31 \times 10 + 20 = 330$

15. Ans: (b)

Sol: Iteration 1: Search through all 'n' nodes

Iteration 2: Search through all 'n–1' nodes

Iteration 3: Search through all 'n–2' nodes

and so on.

$\therefore$ Total $= \frac{n(n+1)}{2}$

16. Ans: 18

17. Ans: (c)

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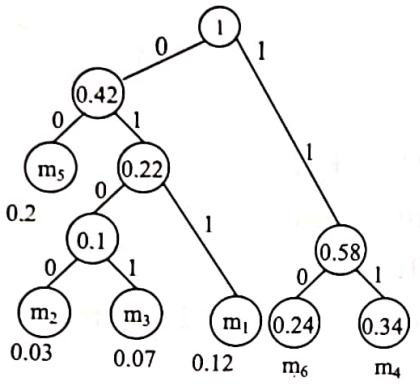
18. Ans: (c)

Sol: Short path from a to i is $a \xrightarrow{1} c \xrightarrow{6} f \xrightarrow{2} i$

19. Ans: (d)

Sol:



$m_1 \to 011$ | $m_3 \to 0101$ | $m_5 \to 00$
$m_2 \to 0100$ | $m_4 \to 11$ | $m_6 \to 10$

10 10 10 11 10 0101

m_6 m_6 m_6 m_4 m_6 m_3

20. Ans: (a)

Sol: It takes O(n). First assign highest denomination if possible then next continue this.

21. Ans: (a)

Sol: A_1 and A_2 has $\frac{n}{2}$ elements each, to find record movements it requires n time.

22. Ans: (b)

i:	1	2	3	4	5	6	7	8
P_i:	90	61	50	33	29	23	15	13
W_i:	33	30	25	17	15	12	10	9
P_i/W_i:	2.72	2.03	2	1.941	1.933	1.916	1.5	1.44

M = 92	Remaining capacity	Profit
Select item 1 →	92 – 33 = 59	90
Select item 2 →	59 – 30 = 29	90 + 61 = 151
Select item 3 →	29 – 25 = 4	151 + 50 = 201
Select time 4, 4/17 →	$4 - 17 \times \frac{4}{17} = 0$	$201 + 33 \times \frac{4}{17}$ = 208.764

(1, 2, 3, 4) are included

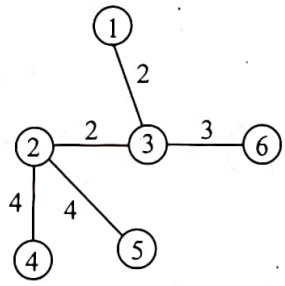
(5, 6, 7, 8) are not included

23. Ans: (a)

Sol: Approximately 209

24. Ans: (d)

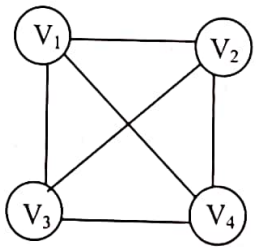
Sol:



(1, 2) is not included

25. Ans: (d)

Sol:



Every node is connected with every other node

$\therefore n^2$ possible paths, n = 4.

16 spanning trees

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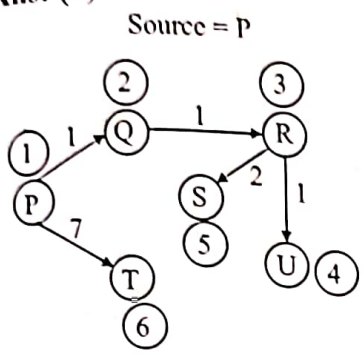
26. Ans: (b)

Sol:



$P \to Q^{P=Q}$, R, U, S, T

$P \to R \Rightarrow P \to Q \to R = 2$

$P \to S \Rightarrow P \to Q \to R \to S = 4$

$P \to T = 7$

$P \to U \Rightarrow P \to Q \to R \to U = 3$

27. Ans: (c)

Sol: $n = 7$

Dead Line	0 – 1	1 – 2	2 – 3	3 – 4
Assigned Job	P_6	P_7	P_4	P_3
Cost	6	30	18	20

Total cost = 74

28. Ans: (a)

Sol: $Z_1 = A + D = 15$

$Z_2 = Z_1 + C = 15 + 15$

$= 30$

$Z_3 = B + E = 20 + 25$

$= 45$

$Z_4 = Z_2 + Z_3 = 30 + 45$

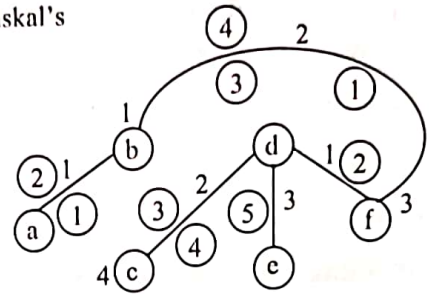
$= 75$

$= 75 + 45 + 30 + 15$

$= 165$

29. Ans: (d)

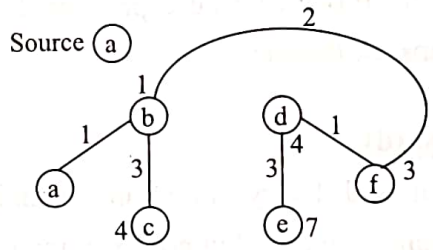
Sol: Kruskal's



cost = 9

30. Ans: (a)

Sol: Dijkstra's single source shortest path



cost = 10

31. Ans: (d)

Sol: order of inclusion

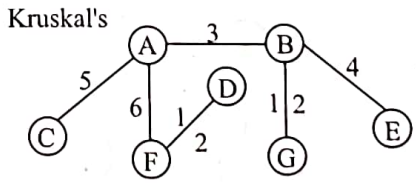
(a–b) (d–f) (d–c) (b–f) (d–e)

any order any order

(d) is correct

32. Ans: (c)

Sol:



(a) → False (b) → False

(c) → True (d) → False

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33. Ans: (a)

Sol: Find $\frac{P_i}{W_i} \Rightarrow \frac{1}{3}, \frac{4}{5}, \frac{5}{6}$.

$\Rightarrow 0.33, 0.8, 0.83$

Select 3rd one first

Capacity = m = 10

Remaining capacity after 3rd element is 4 now 4/5 part of the 2nd item (0,4/5,1)

34. Ans: (b)

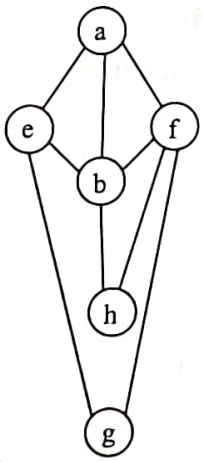
Sol: Greedy Method produces the solution to the given problem because problem looks like knapsack Problem.

35. Ans: (d)

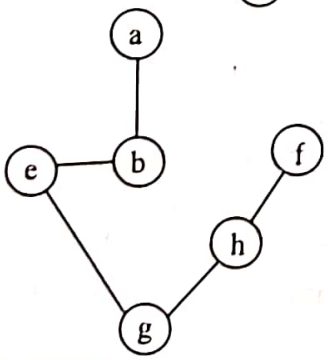
Sol: Each and Every minimum spanning tree contains edge 'k' but not spanning tree.

36. Ans: (a)

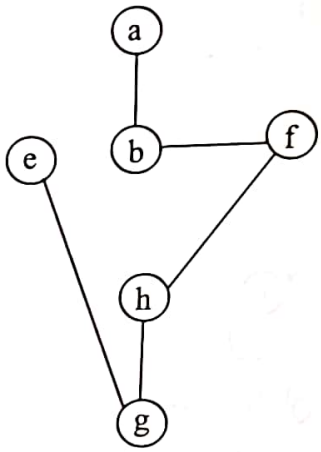
Sol:



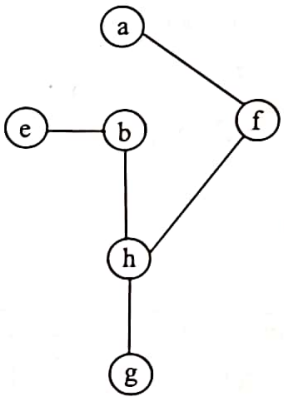
Begin from 1.



2.



4.



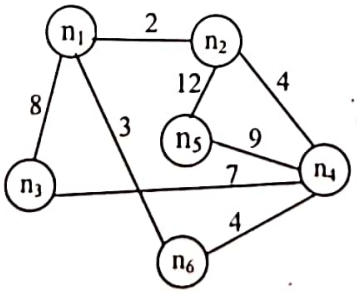
37. Ans: (c)

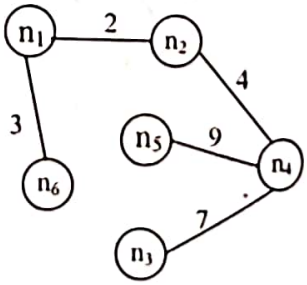
Sol: Graph G has multiple distinct MST's Each of cost n –1.

Every vertex is connected to every other vertex with cost 1.

38. Ans: (b)

Sol: $n_1 \rightarrow n_2$, $n_1 \rightarrow n_6$, $n_2 \rightarrow n_4$, $n_4 \rightarrow n_5$, $n_4 \rightarrow n_3$





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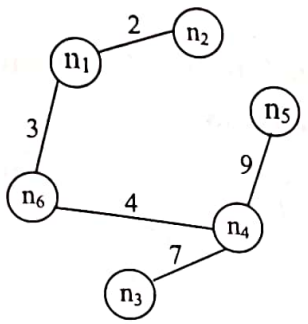
39. **Ans: (b)**

Sol:



40. **Ans: (d)**

Sol: → T^1 is a minimum spanning tree if T is connected since T^1 is a subgraph of T induced by V^1.

→ If the graph contains n vertices then apply single source shortest path for all the n vertices by considering each vertex as a source.

→ Breadth First Search (BFS) finds the diameter of a tree.

41. **Ans: (a)**

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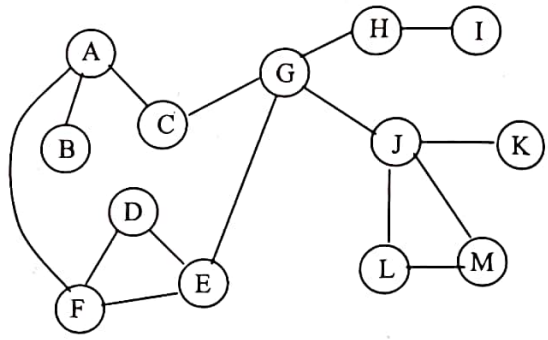
Chapter 4 Graph Techniques, Components, Heaps

01. Which Data Structure is used in the implementation of Topological sort?
(a) STACK
(b) Queue with FIFO discipline in arrays
(c) Queue with LIFO discipline in arrays
(d) Priority Queue

02. If the numbers 7, 5, 1, 8, 3, 6, 0, 9, 4, 2 are inserted in that order into an initially empty min-Heap, then the total number of comparisons made are _____.
(a) Exactly 10
(b) Less than 10
(c) Greater than 10
(d) 5

03. Which of the following is ***true***?
(a) DFS and BFS when carried out over a directed graph from a particular vertex, always generates a unique spanning tree
(b) DFS traversal can be used to find the shortest paths from a vertex in a unit cost weight graph.
(c) DFS when carried out over a directed acyclic graph can generate a topological sort sequence
(d) BFS is used in Backtracking technique

Common Data for Questions 04, 05 & 06 are given below:



04. How many connected components does the graph has?
(a) 1 (b) 3 (c) 4 (d) 5

05. The number of Biconnected components of the graph is :
(a) 11 (b) 10 (c) 2 (d) 6

06. The minimum number of edges that need to be added to make it biconnected?
(a) 2 (b) 3 (c) 4 (d) None

07. Let 'T' be a depth first search tree; let 'x' & 'y' be nodes in T; let (x, y) be an edge of G that is not an edge of T; then which is ***true*** with respect to 'x' & 'y';
(a) Neither x nor y are ancestor nor descendents.
(b) One of x or y is an ancestor of the other
(c) There must be a cross edge between x & y in the tree.
(d) x must always be a descendent of y

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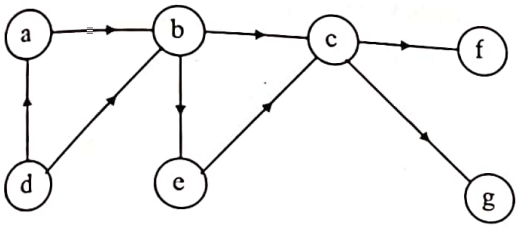
08. Consider the following directed graph



Which of the following is not a valid topological sort sequence?

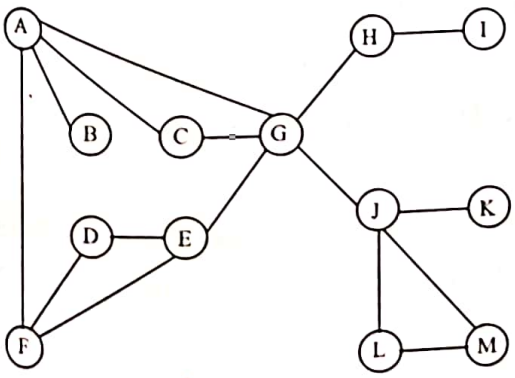
(a) d, a, b, e, c, g, f
(b) d, a, b, c, e, f, g
(c) d, a, b, e, c, f, g
(d) all are valid

09. Consider the depth first search of an undirected graph with 4 vertices A, B, C and D. Let discovery time d(u) represent the time instant when the vertex 'u' is first visited, and the finish time f(u) represent the time instant when the vertex 'u' is last visited. Given that

d(A) = 2, f(A) = 10;
d(B) = 4, f(B) = 6;
d(C) = 7, f(C) = 9;
d(D) = 12, f(D) = 15;

In that graph how many connected components are there_____.

10. The number of articulation points of the below graph G is_____.



11. Given a directed graph G represented as adjacency list, how much time does an efficient algorithm takes to find all the strongly connected components of G?

(a) O(V+E)
(b) O(E)
(c) O(E log V)
(d) O(E log E)

12. Which of the following are ***not*** the properties of binary heap?

(a) It is a complete binary tree with no order among the elements.
(b) It is an array without empty slots among the elements.
(c) It is structurally complete binary tree and every non-leaf element in it is smaller/greater than its children.
(d) Both b and c

13. An undirected graph with 'n' vertices and 'e' edges are represented by adjacency matrix. The time required to determine the degree of any vertex 's' is.

(a) O(e)
(b) O(n)
(c) $O(n^2)$
(d) O(e + n)

14. Which of the following sequences of array elements forms a heap?

(a) {23, 17, 14, 6, 13, 10, 1, 12, 7, 5}
(b) {23, 17, 14, 6, 13, 10, 1, 5, 7, 2}
(c) {23, 17, 14, 7, 13, 10, 1, 5, 6, 12}
(d) {23, 17, 14, 7, 13, 10, 1, 12, 5, 7}

15. Consider the directed graph given below: How many Strongly Connected components, in the given graph have?

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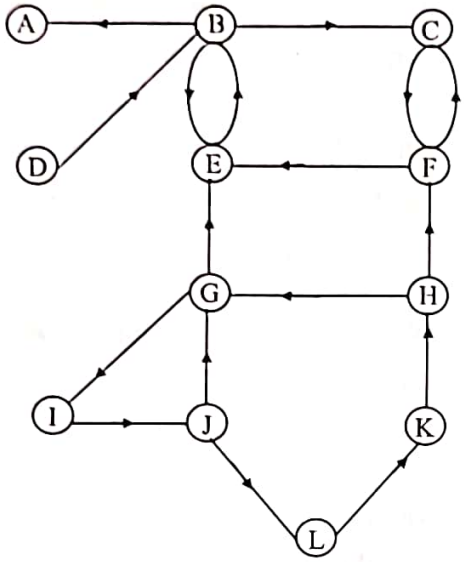
(a) 4
(b) 6
(c) 3
(d) 5



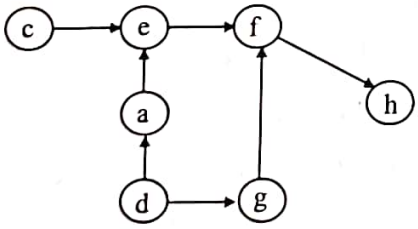
16. Construct a min-heap from the following sequence of integer elements:

120, 140, 40, 50, 80, 70, 60, 90, 20, 100

After deleting a root element from the heap, what will be the post-order traversal of the heap?

(a) 140 100 90 80 50 120 70 60 40
(b) 140 100 90 80 120 70 50 60 40
(c) 140 100 80 90 120 70 50 60 40
(d) 140 90 100 50 80 40 120 60 70

17. The topological sort of the following directed acyclic graph is

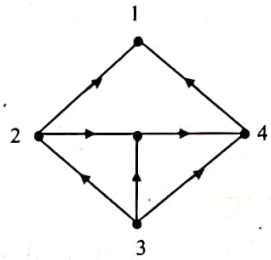


(a) c – d – a – e – g – f – h
(b) c – d – a – g – e – f – h
(c) c – d – g – a – e – f – h
(d) All of the above

18. An undirected graph with 'N' vertices and 'E'edges is represented by an adjacency matrix. What is the time required to determine if the graph is connected?

(a) O(E) (b) O(N)
(c) $O(N^2)$ (d) O(E + N)

19. Which of the following sequences represent the topological sort sequence for the following graph:



(a) 2, 1, 3, 4, 1 (b) 5, 2, 4, 3, 1
(c) 4, 3, 2, 1, 5 (d) 5, 2, 3, 4, 1

20. Consider the following statements regarding graph traversals.

I. The graph traversals are always unique whereas there can be multiple tree traversals for a given tree and order.
II. If the graph G is represented by it's adjacency matrix, then the graph traversals timing complexity is $O(n^2)$.
III. It is always possible to construct the graph uniquely, given DFS & BFS.
IV. DFS is efficient than BFS always.

Which of the above statements are ***false***?

(a) I, III only (b) II, III & IV
(c) I, III, IV (d) I, II, III & IV

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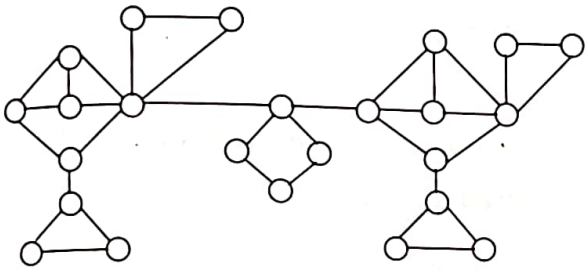
21. A maximal connected subgraph which does not contain articulation points and bridges is called biconnected component. Then in the following graph, how many biconnected components are there?



(a) 6 (b) 5 (c) 7 (d) None

22. Which of the following are the heaps?

I. 42, 35, 37, 20, 14, 18, 7, 10

II. 42, 35, 18, 20, 14, 30, 10

III. 20, 20, 20, 20, 20, 20

(a) I, II & III (b) I & II

(c) I & III (d) Only I

23. A simple graph with n-vertices and k-connected components can have at most____.

(a) n edges

(b) n–k edges

(c) (n–k) (n–k–1)/2 edges

(d) (n–k) (n–k+1)/2 edges

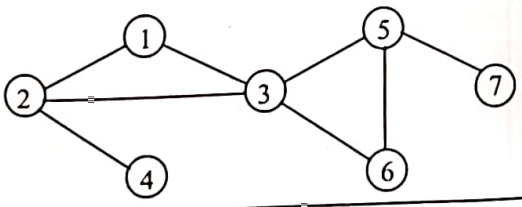
24. The number of articulation points of the following graph is:

(a) 0

(b) 1

(c) 2

(d) 3



25. Which of the following list of elements in the array satisfies Max-Heap property?

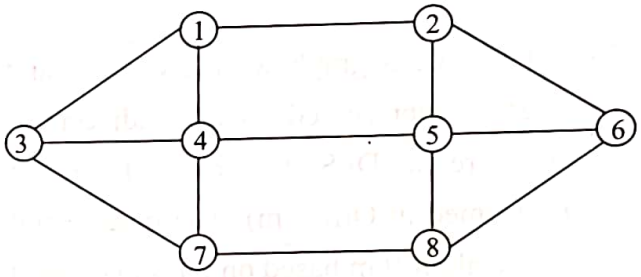
(a) 16, 10, 12, 8, 3, 5

(b) 16, 8, 5, 10, 12, 3

(c) 16, 12, 8, 3, 5, 10

(d) 10, 16, 12, 8, 5, 3

26. Consider the following Graph:



Which of the following is ***Not*** possible BFS sequence if the starting vertex is 1

(a) 1, 3, 2, 4, 7, 5, 6, 8

(b) 1, 2, 3, 5, 6, 4, 7, 8

(c) 1, 2, 3, 4, 5, 6, 7, 8

(d) 1, 4, 2, 3, 7, 5, 6, 8

27. Which one of the following statements is ***false***?

(a) Optimal binary search tree construction can be performed efficiently using dynamic Program.

(b) BFS Cannot be used to find converted components of a graph.

(c) Given the prefix and postfix walks over a binary tree, the binary tree cannot be uniquely constructed.

(d) DFS can be used to find connected components of a graph.

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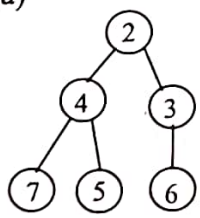
28. Match the following:

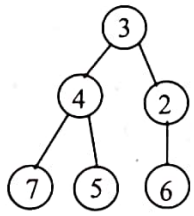
P. O(logn)	1. Heap Sort
Q. O(n)	2. Depth-First Search
R. O(nlogn)	3. Binary Search
S. $O(n^2)$	4. Selection of the kth smallest element in a set of 'n' elements

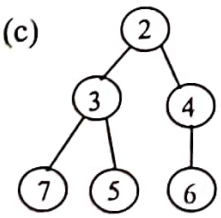
(a) P-1, Q-2, R-3, S-4 (b) P-3, Q-1, R-2, S-4
(c) P-3, Q-2, R-4, S-1 (d) P-2, Q-3, R-1, S-2

29. Let 'G' be a graph with n-vertices and 'm' edges, represented with adjacency list structure a DFS traversal of G can be performed in O(n + m). The time complexity of the algorithm based on DFS to computing a cycle in 'G' or reporting that 'G' has no cycles is
(a) $O(n^2)$ (b) O(n + m)
(c) O(n (n + m)) (d) $O(n^3)$

30. Draw the min heap that results from insertion of the following elements into an initially empty min-heap. 7, 6, 5, 4, 2, 3, 1.
Show the result after the deletion of the root of the heap.

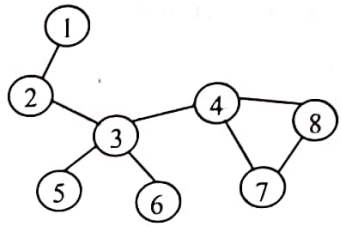
(a)


(b)


(c)


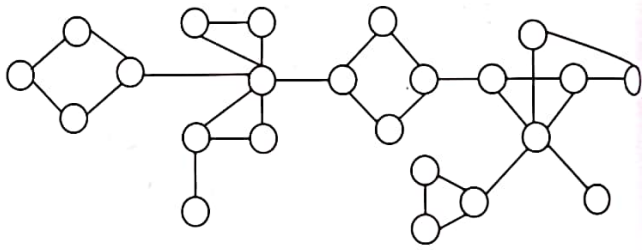
(d) None

31. The number of articulation points of the following graph is:
(a) 2
(b) 3
(c) 4
(d) 5



Statement for Linked answer Q32 and Q33 is given below.

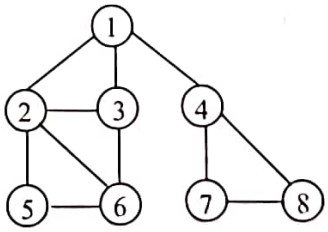
A graph is said to be biconnected, if it does not contain any articulation points and bridges. For the given below identify the number of articulations.

32.


(a) 8 (b) 9
(c) 7 (d) 10

33. How many biconnected components, does the above graph has?
(a) 7 (b) 8
(c) 6 (d) 9

34. Consider the following graph.



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If we suppose that the neighbors of a given node are examined in numerical order, and that '1' is the first node of DFS then which of the following order nodes get visited using DFS algorithm.

(a) 1, 2, 3, 4, 5, 6, 7, 8
(b) 1, 2, 3, 6, 5, 4, 7, 8
(c) 1, 2, 3, 6, 5, 4, 8, 7
(d) 1, 2, 3, 5, 6, 4, 7, 8

35. Which of the following algorithm is useful for Topological sort of the graph?
(a) Prim's algorithm
(b) Kruskal's algorithm
(c) Floyd's algorithm
(d) DFS algorithm

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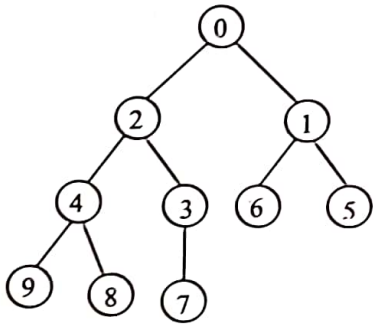
Solutions

01. Ans: (a)

Sol: For topological sort we use DFS. DFS uses stack Data structure.

02. Ans: (c)

Sol: Greater than 10 comparisons.



03. Ans: (c)

Sol: **Options (a):** It is False.

⇒ DFS and BFS generate many spanning trees

Options (b): It is False

⇒ traverses based on depth not on weight

Options(c): It is True

⇒ generates topological sort sequences

Options (d): It is False

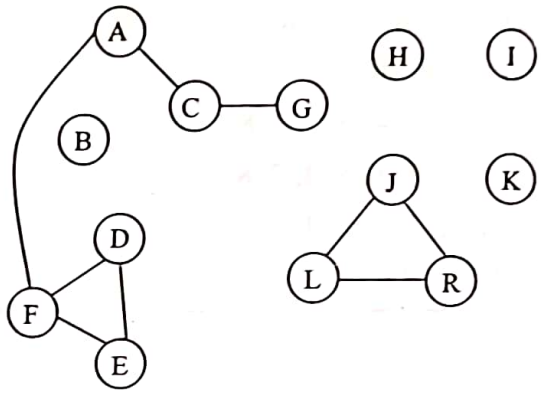
⇒ BFS uses queue not stack.

04. Ans: (a)

Sol: Graph itself is one component.

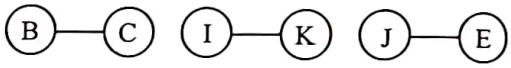
05. Ans: (d)

Sol: 6 – Bi-connected components.



06. Ans: (b)

Sol:



07. Ans: (b)

Sol: x and y are nodes in T

(x,y) be an edge to G but not T implies one of the x or y is an ancestor of the other.

08. Ans: (a & c)

Sol: Delete the vertex which zero inward edges d, a, b, e, c, f, g, (or) d, a, b, e, c, g, f.

09. Ans: 2

Sol: d(A) < d(B) < f(B) < d(C) < f(C) < f(A) and d(D) < f(D). So, A, B, C is one connected Component and 'D' another Component. Number of Connected Components are 2.

10. Ans: 4

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11. Ans: (a)

Sol: Strongly Connected Component is an application of adjacency list, So it takes O(V + E).

12. Ans: (a)

Sol: Heap sort is not stable sort.

It does not preserve the order of the same elements.

Options (b), (c) are properties of Binary Heap.

13. Ans: (b)

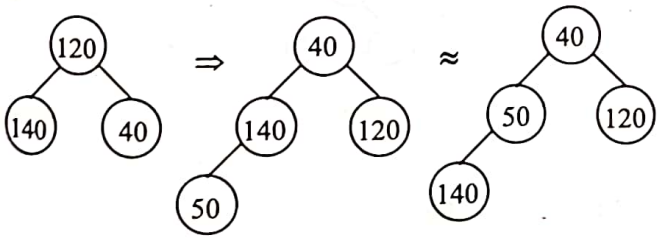
Sol: To find the degree of any vertex count the number of 1's in the particular row of the vertex. This takes O(n) time because there are 'n' vertices.

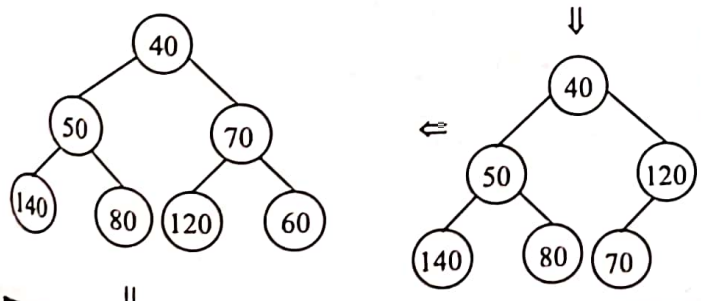
14. Ans: (c) **15. Ans: (d)**

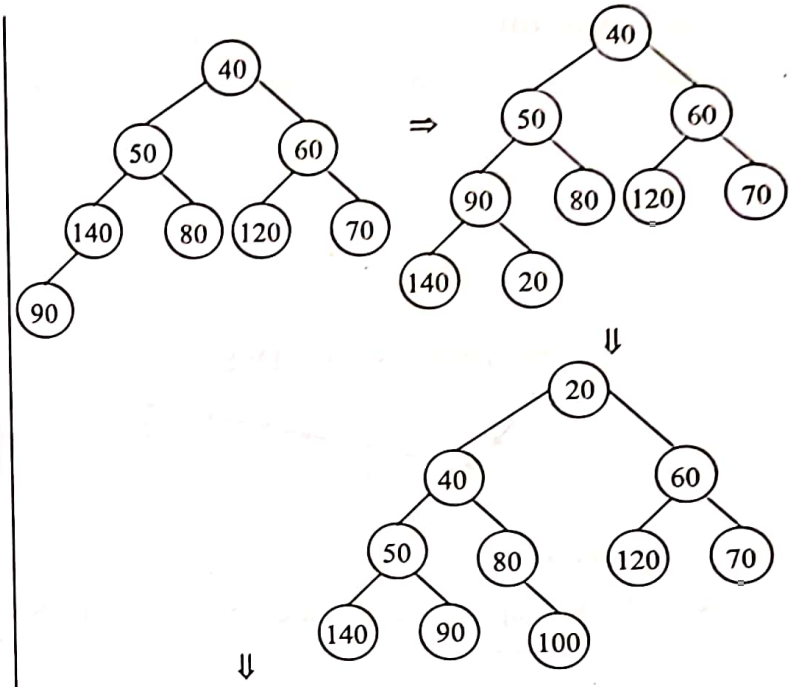
16. Ans: (a)

Sol: min–heap construction:

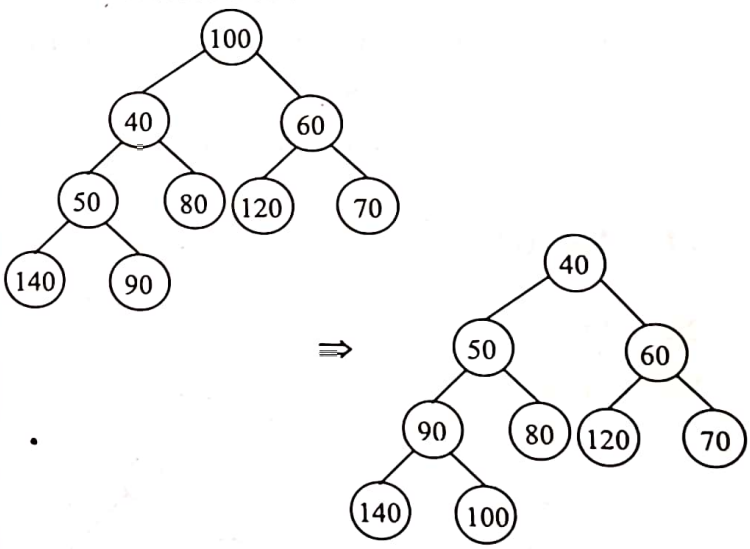
120,140,40,50,80,70,60,90,20,100







Delete the root



Post Order Traversal :

140,100,90,80,50,120,70,60,40

17. Ans: (d)

18. Ans: (c)

Sol: Adjacency Matrix requires N × N locations.

To search N × N matrix it requires N^2 time.

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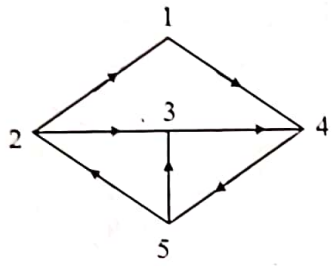
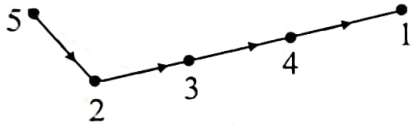
19. Ans: (d)

Sol:



Number the edges using DFS.



20. Ans: (c)

Sol: I → Graph traversals are not unique (DFS, BFS)

II → True

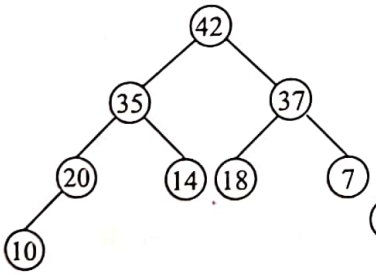
III → Cannot possible to construct using DFS & BFS.

IV → BFS is efficient than DFS.

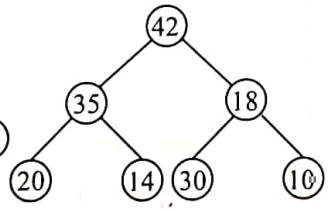
21. Ans: (c)

22. Ans: (c)

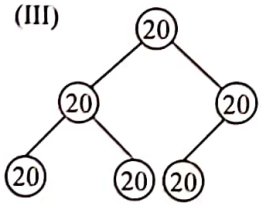
Sol: (I) Heap Construction



(II) Not Heap



(III)



Heap

I & III are Heaps

23. Ans: (d)

Sol: n–Vertices, k–connected components → If you assume each component has one vertex then k–1 has k–1 vertices and k^{th} component has n–k+1 vertices.

k^{th} components has (n–k) (n–k+1)/2 edges

$\therefore$ Total edges = $\dfrac{(n-k)(n-k+1)}{2}$

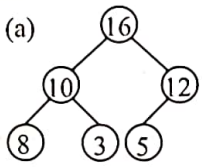
24. Ans: (d)

Sol: Deletion of vertex disconnects then that vertex is articulation point ②, ③, ⑤ are articulation points.

25. Ans: (a)

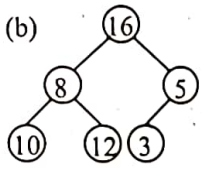
Sol:

(a)



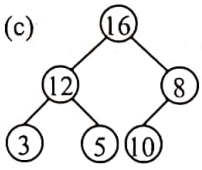
Max–Heap

(b)



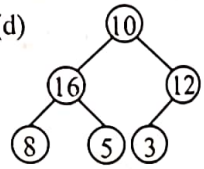
Not Max–Heap

(c)



Not Max–Heap

(d)

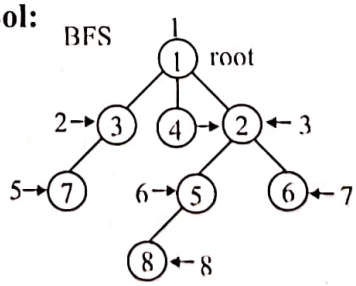


Not Max–Heap

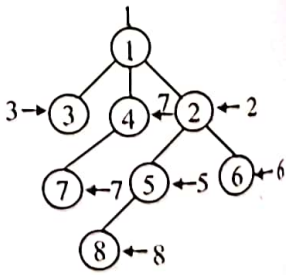
26. Ans: (b)

Sol:

BFS



Option (a)



Option (c)

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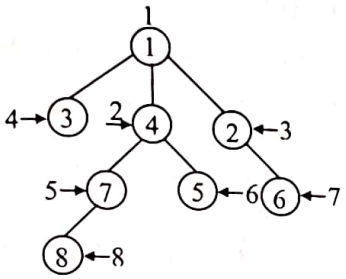


Option (d)

Numbering outside the node is order of traversal (b) is ***not*** possible.

27. Ans: (b)

Sol: → Using Dynamic programming OBST is constructed efficiently

→ Binary tree cannot be constructed using Prefix and Postfix

→ DFS computes connected components.

28. Ans: (c)

Sol: Binary search – $T(n) = T(n/2) + k$

$\Rightarrow O(\log n)$

Depth first search – $O(n) \Rightarrow$ 'n' is number of vertices.

Selection of kth smallest element

$\rightarrow O(n \log n)$ by partition of element.

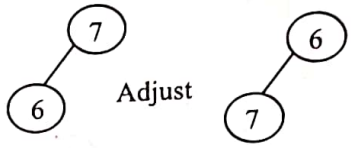
Heapsort worst case time complexity is $O(n^2)$.

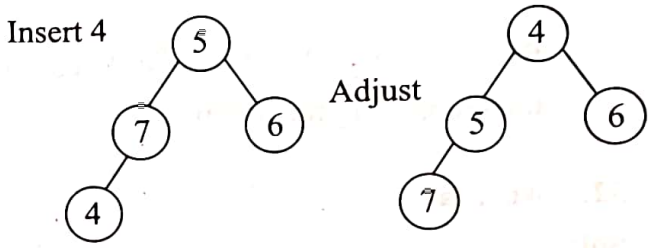
29. Ans: (b)

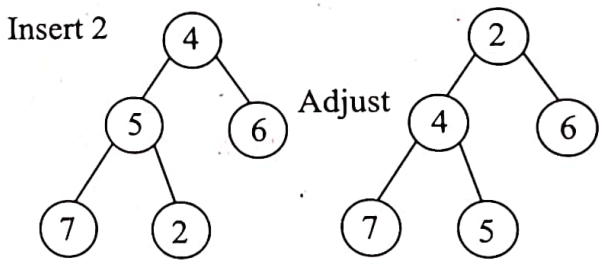
Sol: DFS Traversal can be performed in $O(n+m)$, within this time it reports either cycle in G or no cycle in G.

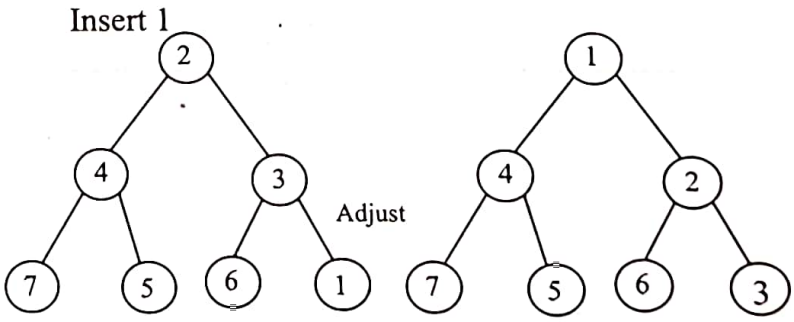
30. Ans: (a)

Sol: Min heap construction

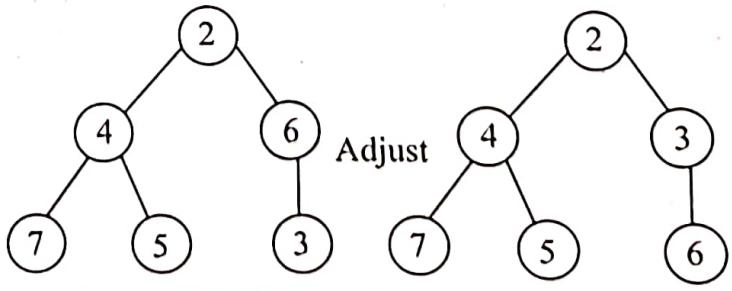








Delete root element 1



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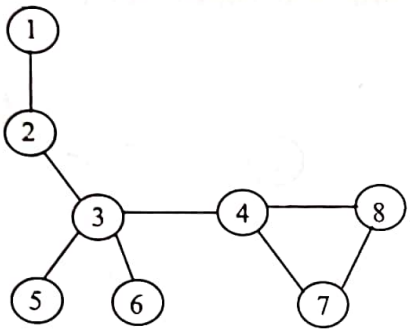
31. Ans: (b)

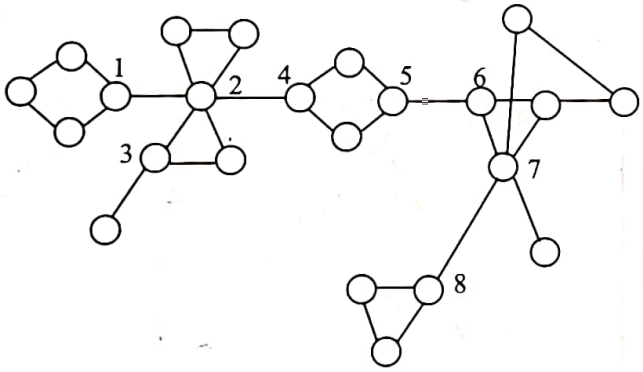
Sol:



Removal of nodes 2, 3 and 4 disconnects the graph 3 articulation points.

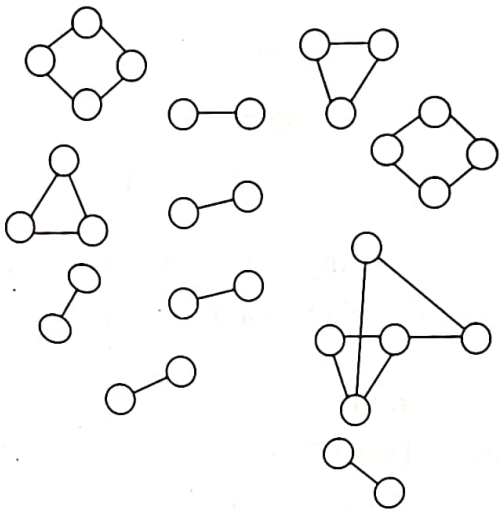
32. Ans: (a)

Sol:



33. Ans: (c)

Sol: A graph is biconnected if and only if it does not have articulation points.



34. Ans: (b)

Sol: By applying DFS algorithm on vertex ①, we can get order of visiting of nodes are 1, 2, 3, 6, 5, 4, 7, 8.

35. Ans: (d)

Sol: DFS algorithm generates Topological sort of the graph.

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Chapter 5 Dynamic Programming

01. Four matrices M_1, M_2, M_3 and M_4 are dimensions $p\times q$, $q\times r$, $r\times s$ and $s\times t$ respectively can be multiplied in several ways with different number of total scalar multiplications. For example When multiplied as $((M_1\times M_2)\times(M_3\times M_4))$ total number of scalar multiplications is pqr + rst + prt. When multiplied as $(((M_1\times M_2)\times M_3)\times M_4)$ the total number of scalar multiplications is pqr+prs+pst.

If p=10, q=100, r=20, s=5 and t=80, then the minimum number of scalar multiplications needed is :

(a) 248000 (b) 44000
(c) 19000 (d) 25000

02. Consider the matrix chain product problem, defined with n-matrices: A_1, A_2. . . where the order of each matrix is $d_{i-1}\times d_i$. It is required to parenthesize the product $(A_1,A_2 \ldots A_n)$ with minimum number of scalar multiplications. Let m(i,j) denote the minimum number of multiplications required to compute the matrix product $A_i \ldots A_j$. The Recursive definition of m(i,j) based on dynamic programming is given below:

M(i, j) = 0, if i = j;
= equation, if i<j;

Which of the following option is ***correct*** for equation?

(a) $\min\limits_{i<k<j} \{m(i,k) + m(k+1,j)+d_{i-1}\times d_k\times d_j\}$

(b) $\min\limits_{i<k\le j} \{m(i,k) + m(k-1,j)+d_i\times d_k\times d_j\}$

(c) $\min\limits_{i\le k<j} \{m(i,k) + m(k+1,j)+d_{i-1}\times d_k\times d_j\}$

(d) $\min\limits_{i\le k<j} \{m(i,k) + m(k,j)+d_{i-1}\times d_k\times d_j\}$

03. Consider the following chain of matrices M_1–M_4 having the dimension given below:

$A_1 \rightarrow 2\times 3$
$A_2 \rightarrow 3\times 5$
$A_3 \rightarrow 5\times 4$
$A_4 \rightarrow 4\times 2$

The following table is filled up using dynamic programming in order to find minimum number of scalar multiplications:

i \ i	1	2	3	4
1	0	30	70	Q
2	0	0	P	70
3	0	0	0	40
4	0	0	0	0

What are the values of P & Q?

(a) 60, 140 (b) 60, 82
(c) 60, 40 (d) 60, 92

04. The recurrence arising for Flyod-Warshell's algorithm in solving problem of all pairs shortest path based on principle of optimality, assuming the cost adjacency matrix of the graph in C[1..n, 1..n], n = number of vertices; A[i, j] = minimum cost path from 'i' to 'j', k is the intermediate vertex of highest index along the path from 'i' to 'j':

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(a) $A_k(i,j) = A_k(i,k) + A_k(k,j)$

(b) $A_k(i,j) = \min[A_k(i,k-1)+A_k(k-1,j), A_{k-1}(i,j)]$

(c) $A_k(i,j) = \min[A_{k-1}(i,k)+A_{k+1}(k-1,j), A_{k-1}(i,j)]$

(d) $A_k(i,j) = \min[A_{k-1}(i,k) + A_{k-1}(k,j), A_{k-1}(i,j)]$

05. Three programs are stored on a magnetic tape of infinite length. Objective is to store the programs on tape so as to minimize the average retrieval time of program. Retrieval time is proportional to the size of file, measured in terms of number of records; the mean retrieval time of three programs of the following length is _____.
$(l_1, l_2, l_3) = (5, 10, 3)$

Common Data for Questions Q06 & Q07 are given below:

Consider the following instance of optimal cost binary search tree;

$n = 3$; (a_1, a_2, a_3) = (do, if, for)

$(p_1, p_2, p_3) = (0.5, 0.1, 0.05)$

$(q_0, q_1, q_2, q_3) = (0.15, 0.1, 0.05, 0.05)$

06. The height of the optimal cost binary search tree constructed based on dynamic programming paradigm is
(a) 2 (b) 3
(c) 1 (d) None

07. The cost of OBST is:
(a) 1.5 (b) 1.8
(c) 2.15 (d) 1.9

08. Consider Two strings A = "q p q r r" and B = "p q p r q r p". Let 'x' be the length of the longest common subsequence (not Necessarily contiguous) between A and B and let 'y' be the number of such longest common subsequence between A and B.
Then x + 10 y = _____.

09. Time complexity of an algorithm to find the longest monotonically increasing subsequence of a sequence of 'n' numbers is:
(a) O(n) (b) O(n logn)
(c) $O(n^2)$ (d) $O(n^2 \log n)$

Statement for Q10 is given below.

Let n = 5 (do, if, int, while).

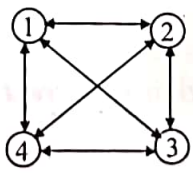
Let p (1.....4) = (3, 3, 1, 1) &

q (0...4) = (2, 3, 1, 1, 1).

10. What is the height of a OBST?
(Assume root is in level 1,
height = highest level-1)
(a) 1 (b) 2
(c) 3 (d) 4

Statement for Q11 is given below.

Consider the following instance of traveling sales person problem:



$$\begin{bmatrix} 0 & 10 & 15 & 20 \\ 5 & 0 & 9 & 10 \\ 6 & 13 & 0 & 12 \\ 8 & 8 & 9 & 0 \end{bmatrix}$$

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11. The minimum cost of the tour is, with starting vertex (1)

(a) 35 (b) 38
(c) 40 (d) None

Common Data for Questions Q12 & Q13 are given below.

Consider the Floyd-Warshall algorithm, gives a dynamic programming solution for the all pairs shortest paths.

D(i, j) is the length of the shortest path from 't' to 'j' for all $i, j \in V$.

If there is no path from 't' to 'j' $D(i, j) = \infty$.

If $i = j$, then $D(i, j) = \phi$;

Let A(k, i, j) be the length of the shortest path from 'i' to 'j' such that all intermediate nodes on the path are in {1, 2, 3…, k} then

$D(i, j) = A(n, i, j)$;

The algorithm computes A(k, i, j) using a recurrence on k,

where $A(0, i, j) = C(i, j), i, j \in V, i \neq j$.

$A(0, i, i) = 0$ for all $i \in V$.

12. Which of the following is the general step in the recurrence, where $1 \leq k \leq n$?

(a) $A(k, i, j) = \min\{A(l, i, k) + A(l, k, j)\}$

(b) $A(k,i, j)$
$= \min\{A(k-1, i, j), A(k-1, i, k) + A(k-1, k, j)\}$

(c) $A(k,i,j) = \min\{C(i, j), A(k,i,k) + A(k,k,j)\}$

(d) $A(k, i,j)$
$= \min\{A(k-1,i,j) + A(k-1, i, k), A(k-1, k, j)\}$

13. What is the running time of the Floyd-Warshall's algorithm?

(a) $\Theta(n^2)$ (b) $\Theta(n^3)$
(c) $\Theta(n^4)$ (d) $\Theta(n^3 \log n)$

Statement for Linked Questions Q14 &Q15 are given below:

Given two strings, X = <x1, x2, …..xm> and Y = <y1, y2, …..yn>.

The Shortest Common Subsequence (SCS) is a minimum length string Z such that both X and Y are subsequences of Z.

14. Following the above definition of SCS, if X = <ABCBABA>; Y = <BCAABAB>, then which of the following may be the candidate for Z?

(a) <ABCAABA>
(b) <BABCAABAABA>
(c) <ABCAABABABAC>
(d) <ABCAABABA>

15. If the above problem is solvable using Dynamic Programming, then the complexity of the algorithm is :

(a) O(m n) (b) $O(n^2 m)$
(c) $O(2^n 2^n)$ (d) O(n log m)

16. Consider the following binary search tree containing three identifiers: (do, if, while); the probability of internal nodes is (0.5, 0.1, 0.05) where as the probabilities of external nodes are (0.15, 0.1, 0.05, 0.05).

The cost of the above tree is

(a) 2.35 (b) 1.9
(c) 2.05 (d) 1.6

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17. Consider the definition of 0/1 knapsack:

Given a set of n–objects and a knapsack of capacity 'w'. Each object has a weight 'w_i' & benefit of 'b_i'. It is required to fill in the knapsack with objects to maximize the benefit, under the condition that the objects are either fully placable or not at all placable in the knapsack. If B(k,w) defines the total value of a subset of S_k from among all those subsets having total weight of 'w'. Given that N(0,w)=0 for all ≤ W. The dynamic programming based recurrence for B(k,w) is described as:

(a) $B[k, w] = B[k-1, w], w_k > W$
$= \max\{B[k-1,w], B[k-1,W-w_k]+b_k\}, w_k \le W$

(b) $B[k, w] = B[k-1, w], w_k > W$
$= \max\{B[k,w-w_k], B[k-1, w] + b_k\}, w_k \le W$

(c) $B[k, w] = \{B[k-1, w], w_k > W$
$= \max\{B[k+1,w], B[k+1,w-w_k]+ b_k\}, w_k \le W$

(d) $B[k, w] = B[k-1, w], w_k > W$
$= \max\{B[k+1, w], B[k+1, w-w_k]\}, w_k \le W.$

18. Match the following:

P. All pairs shortest paths	1. Greedy
Q. Quick Sort	2. DFS
R. Minimum weight Spanning Tree	3. Dynamic programming
S. Connected Components	4. Divide and Conquer

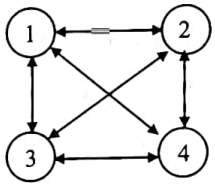
(a) P-2, Q-4, R-1, S-3
(b) P-3, Q-4, R-1, S-2
(c) P-4, Q-1, R-2, S-3
(d) P-3, Q-4, R-2, S-1

19. Match the following:

P. Matrix multiplication	1. Greedy method
Q. Huffman Coding	2. Dynamic programming
R. Biconnected Components	3. Divide and Conquer
S. Reliability Design	4. Depth First Traversal

(a) P-1, Q-2, R-3, S-4
(b) P-3,Q-2,R-4,S-1
(c) P-3, Q-1, R-4, S-2
(d) P-4,Q-1,R-2,S-3

20. Find the least cost path for the traveling sales persons problem



C	1	2	3	4
1	0	10	15	20
2	5	0	9	10
3	6	13	0	12
4	8	8	9	0

(a) 1 – 2 – 3 – 4 – 1
(b) 1 – 3 – 2 – 4 – 1
(c) 1 – 2 – 4 – 3 – 1
(d) None of the above

21. Match the following:

List–I
(1) Bellman – Ford Algorithm
(2) Floyd's – Warshall Algorithm
(3) Huffman Encoding
(4) Prim's – Jarnik Algorithm

List–II
(M) Greedy Method
(N) Dynamic Programming
(O) Divide & Conquer
(P) Biconnected Components

(a) 1-M,2-N,3-O,4-P
(b) 1-P,2-M,3-N,4-O
(c) 1-M,2-N,3-O,4-M
(d) None of these

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Solutions

01. Ans: (c)

Sol: It is based on Dynamic programming. Use the recurrence that arises in this problem and multiply as $(M_1\times(M_2\times M_3))\times M_4 = 19{,}000$ See the recurrence of Matrix Chain Product.

02. Ans: (c)

Sol: Applying principle of optimality over m(i, j) for the product $A_i \ldots A_j$;

03. Ans: (b)

Sol: Matrix chain multiplication

$$M[i,j] = \min_{i\le k<j} \{m[i, k] + m[K + 1, j] + P[i-1]\,P[k]*P[j]$$

$$P = M[2,3] = m[2,2]+m[3,3]+P[1]*P[2]*P[3]$$
$$= 0+0+3*5*4 = 60$$

P = 60

$$Q = M[1,4]$$
$$= \min\{ m[1, 1] + m[2, 4] + P0 * P1 * P4,\ m[1, 2] + m[3, 4] + P0 * P2 * P4,\ m[1, 3] + [4,4] + P0 * P3 * P4\}$$
$$= \min\{0 + 70 + 2 * 3 * 2,\ 30 + 40 + 2 * 5 * 2,\ 70 + 0 + 2 * 4 * 2\}$$
$$= \min\{82, 90, 86\} = \mathbf{82}$$

04. Ans: (d)

Sol: Let $P = < v_i \ldots v_j >$ then any vertex except v_i and v_j can be intermediate vertex. Divide this at K. $v_i \rightarrow v_k \rightarrow v_j$

$$A_k[i,j] = \min\{A_{k-1}[i, j],\ A_{k-1}[i,k]+A_{k-1}[k,j]\}$$

05. Ans: 29

Sol: The Greedy Method suggests that store the programs in increasing order of their lengths 3,

$3 + 5 = 8$

$3 + 5 + 10 = 18$

total $= 3+3+5+3+5+ 10 = 29$

06. Ans: (a)

Sol: OBST $c[i,j] = \min_{i<k\le j} \{c[i,k-1]+c[k,j]\} + w[i,j]$;

$w[i,i]=q[i], w[i,j]=w[i,j-1]+P[j]+q[i], r[i,j]=k$

c	0	1	2	3
0	0.15	1	1.45	
1		0.1	0.4	0.7
2			0.05	0.25
3				0.05

w	0	1	2	3
0	0.15	0.75	0.9	1
1		0.1	0.25	0.35
2			0.05	0.15
3				0.05

R	0	1	2	3
0		1	1	1
1			2	2
2				3
3				

$w[0,1] = 0.15+0.5+0.1=0.75$

$w[0,2] = 0.75+0.1+0.05=0.9$

$w[0,3] = 0.9+0.05+0.05=1$

$w[1,2] = 0.1+0.1+0.05 = 0.25$

$w[1,3] = 0.25+0.05+0.05 = 0.35$

$w[2,3] = 0.05+0.05+0.05 = 0.15$

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$c[0,1] = c[0, 0] + c[1, 1] + w[0, 1]$

$= 0.15 + 0.1 + 0.75 = 1$

$c[1,2] = c[1, 1] + c[2, 2] + w[1, 2]$

$= 0.1 + 0.05 + 0.25 = 0.4$

$c[2,3] = c[2, 2] + c[3, 3] + w[2, 3]$

$= 0.05 + 0.05 + 0.15 = 0.25$

$c[0,2]$

$= \min\{c[0,0]+c[1,2], c[0,1]+c[2, 2]\}+w[0,2]$

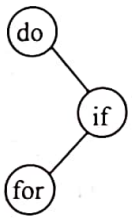
$= \min\{0.15 + 0.4, 1 + 0.05\} + 0.9$

$= 1.45$

$c[1,3] = \min\{0.1+0.25, 0.4+0.05\}+0.35 = 0.7$

$c[0,3] = \min\{0.15+0.7, 1+0.25, 1.45+0.05\}+1$

$= 1.85$



Height = 2

07. Ans: (b)

08. Ans: 34

Sol: Using LCS algorithm we have x = 4, y = 3

So x + 10y = 4 + 10 (3) = 34

09. Ans: (b)

Sol: Compression using Divide and Conquer

10. Ans: (b)

Sol: P(1…4) = (3, 3, 1, 1),

q(0….4) = (2, 3, 1, 1, 1)

$c[i, j] = \min\{c[i, k-1] + c[k, j]\} + w[i, j];$

$i < k \le j$

where $w[i, j] = w[i, j-1] + p[j] + q[j]$

and $w[i, j] = q[i]$, $r[i, i] = 0$, $c[i, i] = q$

r	0	1	2	3	4
0		1	1	2	2
1			2	2	2
2				3	3,4
3					4
4					

w	0	1	2	3	4
0	2	8	12	14	16
1		3	7	9	11
2			1	3	5
3				1	3
4					1

c	0	1	2	3	4
0	2	13	25	32	40
1		3	11	17	25
2			1	5	11
3				1	5
4					1

$w[0,1] = w[0, 0] + p[1] + q[1] = 2 + 3 + 3$

$= 8$

$w[0,2] = w[0,1] + p[2] + q[2] = 8 + 3 + 1$

$= 12$

$w[0,3] = w[0, 2] + p_3 + q_3 = 12 + 1 + 1 = 14$

$w[0,4] = w[0, 3] + p_4 + q_4 = 14 + 1 + 1 = 16$

$w[1,2] = w[1, 1] + p_2 + q_2 = 3 + 3 + 1 = 7$

$w[1,3] = 9$, $w[4, 4] = 11$

$w[2,3] = w[2,2]+p_3+q_3 = 1+1+1=3$,

$w[2, 4] = 5$

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$w[3,4] = w[3,3] + p_4 + q_4 = 1 + 1 + 1 = 3$

$c[0,1] = c[0,0] + c[1,1] + w[0,1] = 2+3+8$

$= 13$

$c[1,2] = c[1,1] + c[2,2] + w[1,2] = 3+1+7$

$= 11$

$c[2,3] = 5,\ c[3, 4] = 5$

$c[0,2]$

$= \min\{c[0,0]+c[1,2], c[0,1]+c[2,2]\}+w[0, 2]$

$= \min\{2 + 11 , 13 + 1\} + 12 = 25$

$c[1,3]$

$= \min\{c[1,1]+c[2,3], c[1,2]+c[3,3]\}+w[1,3]$

$= \min\{3 + 5, 11 +1 \} + 9 = 17$

$c[2,,4]$

$= \min\{c[2,2]+c[3,4], c[2,3]+c[4.4]\}+w[2,4]$

$= \min\{1 + 5, 5 + 1\} + 5 = 11$

$c[0,3]$

$= \min\{c[0,0]+c[1,3], c[0,1], c[2,3] + c[0,2] + c[3,3]\} + w[0,3]$

$= \min\{2 + 17, 13 +5, 25 + 1\} + 14 = 32$

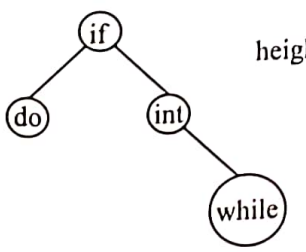
$c[1,4] = \min\{3+11, 11+5, 17+1\}+11$

$= 25$

$c[0,4]$

$= \min\{2+25, 13+11, 25+5, 32+1\}+16$

$= 40$



height = 2

11. Ans: (a)

Sol: Starting Vertex (1)

$$1 \xrightarrow{10} 2 \xrightarrow{10} 4 \xrightarrow{9} 3 \xrightarrow{6} 1$$

12. Ans: (b)

Sol: A(k, i, j)

$= \min(A(k-1, i, j), A(k-1, i, k) + A(k-1, k, j))$

13. Ans: (b)

Sol: $O(n^3)$, It requires 3 for loops

14. Ans: (d)

Sol: Z = <ABCAABABA>

X, Y are sub sequences of Z

15. Ans: (a)

Sol: Largest Common sub sequence Time Complexity = $\Theta(mn)$

Shortest Common sub-sequence also takes $\Theta(mn)$ time.

16. Ans: (a)

Sol: Cost of Tree

$$= \sum_{i=1}^{3} P_i * \text{level}(\text{node}) + \sum_{i=0}^{3} q_i * (\text{level}(\text{External}) - 1)$$

$$= P_1 * \text{level}(\text{do}) + P_2 * \text{level}(\text{if}) + P_3 * \text{level}(\text{while})$$
$$q_0 * (\text{level}(E_0) - 1) + q_1 * (\text{level}(E_1) - 1) +$$
$$q_2 * (\text{level}(E_2) - 1) + q_3 * (\text{level}(E_2) - 1)$$

$= 0.5*2 + 0.1*3 + 0.05*1 + 0.15*2 + 0.1*3 + 0.05 *3 + 0.05 * 1 + 0.05 * 4$

$= 2.35$

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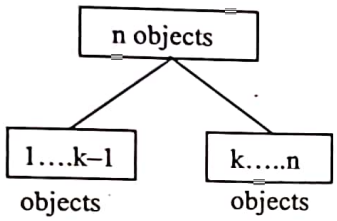
17. Ans: (a)

Sol: Using Dynamic Programming



$$B[k,w]=\begin{cases} B[k-1,w], & w_k > W \\ \max\{B[k-1,w], & B[k-1,W-w_k]+b_k\} w_k \le W \end{cases}$$

18. Ans: (b)

19. Ans: (c)

20. Ans: (c)

Sol: $1 \to 2 \to 3 \to 4 \to 1 \Rightarrow 10 + 9 + 12 + 8 = 39$

$1 \to 3 \to 2 \to 4 \to 1 \Rightarrow 15 + 13 + 10 + 8 = 46$

$1 \to 2 \to 4 \to 3 \to 1 \Rightarrow 10 + 10 + 9 + 6 = 35$

21. Ans : (d)

Sol: Huffman coding uses Greedy method (a), (b) & (c) options are false.

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Data Structures

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Chapter 1 Arrays

01. Consider the following structure

```
struct test
{
    int A [3] [2];      Integer takes – 4 bytes
    char B [10];        Char takes – 1 byte
    float C [2] [2];    float takes – 8 bytes
} struct test * next;
struct test r[20];
```

If the base address of r is 200. What is the address of C [1, 1]?

(a) 246 (b) 420
(c) 484 (d) none

02. Suppose a multidimensional array is declared as

A [1..8, –5..5, –10…..5].

If base address of A is 400 and there are 4 words per memory location, then the address of A[3, 3, 3] by using column major order is

(a) 6300 (b) 4840
(c) 5336 (d) 4700

03. Consider the following Algorithm:

Algorithm pA(x):

Input: An n-element array x of number.

Output: An n-element array A of numbers such that A[i] is the average of elements x[0],……,x[i]

Let A be an array of n numbers

1. for i ← 0 to n – 1 do
2. a ← 0
3. for j ← 0 to i do
4. a ← a+ x[j]
5. A[i] ← a/(i+1)
6. return array A

In the above statement '4' is executed how many number of times

(a) n^2 (b) $\frac{n(n-1)}{2}$

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

04. Match the following:

Matrix	Size
P: Toeplitz	1. 3n – 2
Q: Lower Triangular	2. n (n+1)/2
R: C - matrix	3. n (n–1)/2
S: X - matrix	4. 2n–2
	5. 3n–1
	6. 2n–1

(a) P – 4, Q – 2, R – 6, S – 3
(b) P – 6, Q – 2, R – 1, S – 6
(c) P – 4, Q – 2, R – 6, S – 5
(d) P – 6, Q – 3, R – 4, S – 5

05. Match the following:

Matrix	Location
P : Lower triangular in row major order	1. A[i + 2j – 3]
Q: Upper triangular in column major order	2. A[(j – 1) + i(i –1)/2]
R: Tri-diagonal in row major order	3. A[(i –1) + j(j – 1)/2]
S: Tri-diagonal in column major order	4. A[2i + j – 3]

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(a) P – 2, Q – 3, R – 4, S – 1
(b) P – 1, Q – 2, R – 3, S – 4
(c) P – 3, Q – 2, R – 4, S – 1
(d) P – 2, Q – 3, R – 1, S – 4

Common Data for Q.06 & Q.07

Square Band matrix $D_{n,a}$ is (n × m) matrix in which all the non zero elements lie in a band centered around the main diagonal. The band includes the main diagonal and (a–1) diagonals below and above the main diagonal

06. Which of the following is the size of the matrix?
(a) n (a – 1) – a (a – 1) / 2
(b) (a – 1) (2n – a) + n
(c) 2n (a – 1) – a (a – 1)
(d) $2\left[n(a-1)-\frac{(a-1)}{2}\right]+n$

07. Assume that A is an n × n matrix with A(i, j) = 0, for i + j >= n+2. What are the maximum number of nonzero elements in A?
(a) n (n+1)/2
(b) n (n–1)/2
(c) n^2
(d) $n^2/2$

08. A is one dimensional array A has indices –15....15. Each element takes up two memory words. The array is stored at starting location 1999. The starting address of A[0] element is
(a) 2010 (b) 2029
(c) 2030 (d) 2039

09. If the TOEPLITZ matrix of order (5 × 5) is stored in one dimensional array, then optimum number of elements stored
(a) 9 (b) 10
(c) 11 (d) 25

10. T is a tri – diagonal square matrix of size [1..n, 1..n] in which T[i, j] = 0 unless |i – j| ≤ 1 and stored in an array indexed from 0 to (3n –3). Given the index [i, j], if |i – j| ≤ 1 then the value of T [i, j] is stored in position:
(a) 2 j + i – 3 (b) 2 i + j – 3
(c) 3 j + i – 2 (d) 3 i + j – 2

11. A two dimensional array TABLE [6] [8] is stored in row major order with base address 351. What is the address of TABLE [3] [4]?
(a) 400 (b) 320
(c) 407 (d) 370

Common Data for Q.12 and Q.13

A square band matrix $D_{n,a}$ is a (n × n) matrix in which all the nonzero terms lie in a band centered around the main diagonal. The band includes the main diagonal and (a–1) diagonals below and above the main diagonal.

12. How many elements are there in $D_{6,5}$?
(a) 24 (b) 30 (c) 34 (d) 36

13. If the matrix $D_{4,3}$ is mapped on to a one dimensional array a(0...13) by diagonals, starting with lowest diagonal, then in which location, the elements $D_{0,2}$ is stored.
(a) 24 (b) 13 (c) 20 (d) 12

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14. Consider the following 'C' routine

```
int DO ( int a[ ], int lb, int ub)
{
        int temp;
        if( lb = = ub)
                return a[lb];
        else
        {
                temp =DO( a, lb+1, ub);
                if (a[lb]<= temp);
                        return a[lb];
                else
                        return temp;
        }
}
```

What does DO(a,0,5) return if

a[ ] = {0, –1,10,12,5,8};

(a) –1 (b) 10
(c) 12 (d) 8

15. Consider the following algorithm on array:

Algorithm Do (A, n)
input: An integer array A and an integer n
output: find out

```
        if (n = = 1) then
            return A[0];
        else
            return Do(A, n–1) + A[n–1];
end
```

What does algorithm return for input array A = {4, 3, 6, 2, 5} and Do (A,5) invocation.

(a) Sum of array elements
(b) Maximum of array elements
(c) Minimum of array elements
(d) Reversing the array elements

16. In a matrix a[3*4*5] ,location of a[2][1][3] is (starting location is 0 and size of int is 2 bytes)

(a) 86 (b) 96
(c) 83 (d) 93

17. Consider an array 'a' of dimension 3×4×5×6 starting address of array stored in memory is 0. Find the address of a[2] [2] [3] [4]. (size of element = 1 byte).

(a) 312 (b) 306
(c) 296 (d) 322

18. Given an array a[1…n]. What is the minimum amount of storage required to swap((a[1],…a[n]), (a[2],a[n1]),..(a[(n+1)/2], a[(n+2)/2]))

(a) One temporary element of type 'a' is required.
(b) (n+1)/2 temporary elements of type 'a' are required
(c) (n/2) temporary elements of type 'a' are required
(d) None of the above

19. Suppose there is an integer array M(5,8), the address of M(0,0), M(0,3), and M(1,2) are 100,106 and 120 respectively, what is the address of M(4,5)?

(a) 174 (b) 164
(c) 168 (d) 186

20. A two dimensional array data[5][6] is stored in column major order with base address 301. What is the address of data [2] [4]?

(a) 323 (b) 326
(c) 321 (d) 423

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21.
```
int WhatamIdoing( int * intArray, int size)
{
  int *localArray = malloc(sizeof(int) * size), i,
                                        j, last;
  for ( i = j = 0; i < size; i++)
  if (*(intArray+i) % 2 == 0)
  *(localArray + j++) = *(intArray + i);
  for ( i = 0; i < j; i++)
  *(intArray + i) = *(localArray + i);
  for (last=*(intArray + i–1); i < size; i++)
  (intArray + j++) = last;
  return j;
}
```

If the above routine is traced on ascending order of an array containing the elements [2,4,5,7,8,9,10] then what are the contents of that array:

(a) [2,4,8,10,10,10,10] (b) [2,4,8,10,5,7,9]
(c) [10,9,8,7,5,4, 2] (d) [5,7,9,9,9,9,9]

22. A tri-diagonal matrix [–2..2, 5..9] is stored in row major order with base address 301. What is the address of data [0] [8] if nonzero elements are stored?

(a) 308 (b) 309
(c) 321 (d) 307

Common Data for Q.23 and Q.24 is given below.

A two dimensional array [10] [9] is stored in column major order with base address 29. The array contains numbers 1 to 90 stored in increasing order row wise. Each element in the array takes two memory words.

23. What is the element present at address 67?

(a) 20 (b) 19
(c) 82 (d) 83

24. What is the address of the element array[6][7]?

(a) 161 (b) 105
(c) 147 (d) 163

25. Match the following?

List – I (Square Matrix)	List – II (Number of Nonzero and unique elements)
P: Tri-diagonal	A : N^2
Q: Toeplitz	B : 2N–1
R: Symmetric	C : 3N –2
	D : $N\left(\frac{N+1}{2}\right)$
	E : $N\left(\frac{N-1}{2}\right)$

(a) P – C; Q – B ; R – D
(b) P – B; Q – D ; R – C
(c) P – C; Q – A ; R – D
(d) P – C; Q – B ; R – E

Common Data for Q.26 and Q.27 is given below.

An array A is declared as follows:

A: Array of [1...1000, 1...1000] of elements. Assume the starting location of the array is 1000. Each element occupies one memory cell. The nature of elements are Symmetric. Either lower or upper triangular elements can be stored. The address of the element A(789, 800) is desired.

[**Hint:** Matrix M is Symmetric matrix if M(i, j) = M(j, i) for all i and j].

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26. If the above elements are stored in Row major order for the lower triangular elements, then the address of the desired element is
(a) 311665 (b) 312665
(c) 789799 (d) 800788

27. If the above elements are stored in Column major order for the upper triangular elements, then the address of the desired element is
(a) 311665 (b) 321388
(c) 789799 (d) 800788

28. If the TOEPLITZ matrix of order (7×7) is stored in one dimensional array, then optimum number of elements stored are:
(a) 13 (b) 15
(c) 49 (d) 24

29. Let 'A' be a two dimensional array declares as follows:
A: array [1.....15] [1....20] of integer
Assume that integer takes memory locations the array is stored in column-major order and the first element of the array is stored at location 150. What is the address of the element A[i][j]?
(a) i + 15j + 134 (b) 15i + j + 134
(c) i – 15j + 134 (d) 15i –j +134

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Solutions

01. Ans: (d)

Sol: Base address of r = 200

One structure variable takes 3 * 2* 4 bytes for A, 10 * 1 bytes for B and 2 * 2* 8 bytes for C. Total memory is 24 + 10 + 32 = 66 bytes.

Loc. of C[1,1]=base address+24 +10+((1–0) *2 + 1 – 0) * 8

= 200 + 24 + 10 + 24

= 234 + 24

= 258

02. Ans: (c)

Sol: Row major order

Loc A[i, j, k]

= Base address +(i–1) r_2*r_3 + (j–1)r_3+(k–1)

Column major order

Loc A[i, j, k]

= Base address + (k – 1) r_1r_2 + (j–1) r_2+(i– 1)

$r_1 = 8, r_2 = 10, r_3 = 15,$

$b_1 = 1, u_1 = 8, b_2 = -5,$

$u_2 = 5, b_3 = -10, u_3 = 5$

= Base address + [(k – b_3) (u_1 – b_1 + 1) (u_2–b_2+1) + (j– b_2) (u_2–b_2+1)+ (i–b_1)] * 4

A[3, 3, 3] = 400 + [(3–(–10)) (8 – 1 +1) (5 – (–5) +1)+(3 – (–5)) (5 (–5) +1) +(3– 1)] * 4

= 400 + [13 * 8 * 11 + 8 * 11 +2] * 4

= 5336

03. Ans: (c)

Sol: i = 0 .... n – 1

j = 0 i

when i = 0

j runs 1

i = 1

j runs 2

i = 2

j runs 3

:

:

i = n – 1

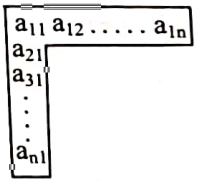
j runs n

total runs = 1 + 2 + 3 + ... +n = $\frac{n(n+1)}{2}$

04. Ans: (b)

Sol:

Toeplitz–



2n–1 elements

Lower Triangular : $\frac{n(n+1)}{2}$

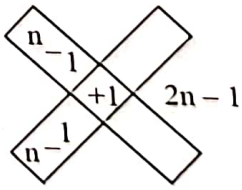
⇒ diagonal – n

below diagonal : n – 1, n – 2, n – 3,..... 1

= n + n – 1 + ... + 1 = $\frac{n(n+1)}{2}$

C– Matrix : 3n – 2

X – matrix :



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05. Ans: (a)

Sol: P: Lower Triangular matrix RMO:

$$A[(j-1) + i(i-1)/2]$$

Q: Upper Triangular matrix CMO:

$$A[(i-1) + j(j-1)/2]$$

R: Tri diagonal in RMO: $A[2i + j - 3]$

S: Tri diagonal in CMO: $A[i + 2j - 3]$

06. Ans: (b)

Sol: Total number of elements

$$= n + 2[n - 1 + n - 2 + \ldots + n - (a - 1)]$$

$$= n + 2[(a-1)n - (1 + 2 + \ldots + (a-1))]$$

$$= n + 2\left[(a-1)n - \left(a\left(\frac{a-1}{2}\right)\right)\right]$$

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

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

07. Ans: (a)

Sol: When $i = 1, j = 1, 2, \ldots n \rightarrow n$ elements

When $i = 2, j = 1, 2, \ldots n - 1 \rightarrow n - 1$ elements

When $i = 3, j = 1, 2, \ldots n - 2 \rightarrow n - 2$ elements

When $i = n, j = 1 \rightarrow 1$ element

Total number of elements $= 1 + 2 + \ldots + n$

$$= \frac{n(n+1)}{2}$$

08. Ans: (b)

Sol: Starting address = base address = 1999

Address of A[i] = base address + $(i - lb) \times c$

$c = 2$

$lb = -15$

Address of A[0] $= 1999 + (0 - (-15)) \times 2$

$= 1999 + 30 = 2029$

09. Ans: (a)

Sol: Number of elements in Toeplitz is $2n-1$

10. Ans: (b)

Sol: 0 1 2 3 4 5 6 7 8 9

$a_{11}\ a_{12} \mid a_{21}\ a_{22}\ a_{23} \mid a_{32}\ a_{33}\ a_{34} \mid a_{43}\ a_{44}$

$$3i - 4 + j - (i - 1) = 2i + j - 3$$

11. Ans: (c)

Sol: TABLE [6] [8]

Base address 351

Let us assume that TABLE[6] [8] is of type integer.

The formula for row major form to calculate address is

Loc(a[i] [j]) = base (a)+w [n (i–lbr) + (j–c)]

Where

n number of column in array

w number of bytes per storage location

*l*br lower bound for row index

*l*bc lower bound for column index.

Loc(TABLE[3] [4]) = 351 + 2[8(3–0)+ (4–0)]

= 351 +2[24+4]

= 351 + 56 = 407

12. Ans: (c)

Sol: Total number of elements in square band matrix $= n + (a - 1)(2n - a)$

$D_{6,5} \Rightarrow n = 6, a = 5$

Number of elements $= 6 + 4(12 - 5)$

$= 6 + 28 = 34$

13. Ans: (d)

Sol: Starting with lowest diagonal $D_{0,2}$ is last but one. It will be stored at 12

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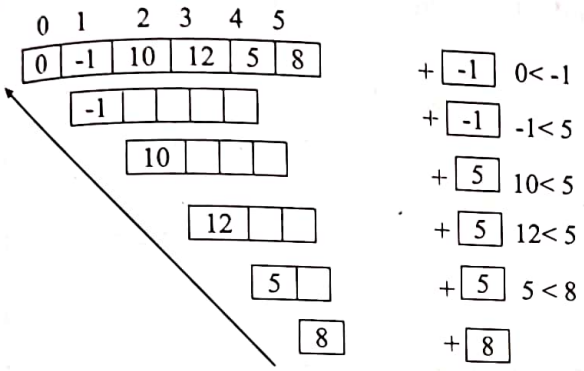
14. **Ans: (a)**

Sol:



15. **Ans: (a)**

Sol: The recursive routine adds the elements of all array elements.

16. **Ans: (b)**

Sol: Loc. a[2][1][3] = 0+ 2*4*5*2 +1*5*2+ 3*2
= 96

17. **Ans: (d)**

Sol: Loc = 0+ 2*4*5*6 + 2*5*6 + 3*6 + 4 = 322

18. **Ans: (a)**

Sol: To swap all the pairs it requires one temporary variable.

Ex: a = a[1]
a[1] = a[n],
a[n] = a

19. **Ans: (a)**

Sol: M(5, 8) ⇒ number of rows = 5
⇒ number of columns = 8

Index begin from 0

base address → Starting address = 100

(address of M(0, 0) = 100)

address of M(0, 3) = 106

⇒ Row major order and size is 2 bytes

Address of M(4, 5)

= Base address + [(i) * column size + j] * number of bytes

=100 + (4 * 8 + 5) * 2 = 174

20. **Ans: (a)**

Sol: Column major order

Address of data [i] [j]

= base address+[(j–b_2)*(u_1–b_1+1)+(i–b_1)]* c

c = 1, b_2 = 0, b_1 = 0, u_1 = 4, u_2 = 5

Address of data[2] [4] = 301+[4* 5 + 2] *1
= 323

21. **Ans: (a)**

Sol: First for loop copies all even numbers to local array.

Second for loop copies all local array elements into intArray.

intArray [ ] = {2, 4, 8, 10, 8, 9, 10}

Third for loop replaces 8, 9, 10 by 10, 10, 10

22. **Ans: (a)**

Sol: Base address = 301

memory size c = 1

Address of A[i, j] = base address + [number of elements in (i–1) rows + (j – j /b)] × 1
= 301 + 3 + 4
= 308

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23. Ans: (d)

Sol: Address of A[i,j]

= base address+[(j–j/b) × number of rows + (i–i/b)] × c

67 = 29 + [(j–1) × 10 + (i–1)] × 2

10j + i – 11 = 19

10j + i = 30

i = 10, j = 2

10th row 2nd column

24. Ans: (c)

Sol: Address of A[6,7] = 29 + [9(j–1) + (i–1)] × 2

= 29+[9×6 + 5] × 2

= 147

25. Ans: (a)

Sol: P: Tridiagonal = 3N – 2

Q: Toeplitz = 2N – 1

R: Symmetric: row 1 → N

row 2 → N – 1

row N → 1

total = 1 + 2 + 3 + ... + N

$= \frac{N(N+1)}{2}$

26. Ans: (b)

Sol: Base address = 1000

c = 1

Address of A[i, j]

= Base address + [i (i –1)/2 + j –1] * c

Address of A[789,800]

= 1000 + 789 * 788/2 + 799

= 312665

27. Ans: (b)

Sol: Column Major order, c = 1

Address of A[i, j]

= Base address+[j (j –1)/2 +(i –1)] * c

Address of A[789,800]

= 1000 + 800 * 799/2 + 788

= 321388

28. Ans: (a)

Sol: Optimum number of elements = 2*n –1

= 2*7 –1

= 13

29. Ans: (a)

Sol: CMO = $L_0 + (j-1)r_1 + (i-1)$

= 150 + (j–1)15 + (i – 1)

= 150 + 15j –15 + i –1

= 150 + 15j + i –16

= i + 15j + 134

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Chapter 2 Stacks & Queues

01. Evaluate postfix expression
6, 2, 3, +, –, 3, 8, 2, /, +, *, 2, ↑, 3, +

(a) 744 (b) 52
(c) 1728 (d) 131

02. Consider the recursive Pseudo code:

```
Algorithm xyz (t, S)
{
    k = S . size( );
    while (!S . isEmpty ( ))
    {
        S . pop ( )
        t ++ ;
        // S : a new stack of size k – 1
        xyz ( t, S);
    }
}
```

Starting with the call xyz (0, S), where S is a stack of n elements {1, 2, 3,..... n}, then the above algorithm does

(a) Reversing n numbers
(b) Descending order of n numbers
(c) Permutations of n numbers
(d) Factorial of n.

03. What does the following recursive function do

```
Dosomething(Q)
{
  if (! isEmpty(Q))
   temp = dequeue (Q);
   Dosomething(Q);
   enqueue (temp, Q);
}
```

(a) Implementation of stack using Queue
(b) Printing elements of Queue
(c) Reversing elements of Queue
(d) Printing elements of Queue in reverse without changing the Queue contents

04. Evaluate 3 – 2 * 4 ↑ 1 * 2 ↑ 3

A: – is highest followed by *, followed by ↑ (lowest) and all are left associative.
B: – is highest followed by *, followed by ↑ (lowest) and all are right associative.
C: Original precedence and associativity.

(a) A > B > C (b) A < B < C
(c) C < A < B (d) C < B < A

05.
```
void TOH( int n, int L, int M, int R)
{   if (n!= 0)
    {
      TOH (n–1, L, R, M);
      Move from L to R
      // Ignore syntactical error
      TOH(n–1, M, L, R);
    }
}
```

Match the following by considering above function if N = number of disks:

P: N = 50, First move after how many calls	1. 31
Q: N = 5, how many moves	2. 62
R: N = 6, how many calls	3. 51
S: N = 5, last move after how many calls	4. 63
	5. 127
	6. 50

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(a) P – 3, Q – 2, R – 6, S – 4
(b) P – 3, Q – 6, R – 2, S – 5
(c) P – 3, Q – 1, R – 5, S – 2
(d) P – 4, Q – 3, R – 2, S – 1

06.
```
void str (char * s)
{
    if ( *s ! = NULL)
    {
        str (s+1);
        str (s+1);
        printf ("% s", *s);
    }
    main ()
    {
        str ("xyz");
    }
}
```

(a) zzyzyzxyz (b) zzyzxyz
(c) zzyzzzyzxyz (d) none

07. What is the value of the postfix expression 6 3 2 4 + - *:
(a) Something between –15 and –100
(b) Something between –5 and –15
(c) Something between 5 and –5
(d) Something between 5 and 15

08. The following routine making use of two queues : Q1,Q2 and one stack :S Initially the queue Q1 contains 5, 6, 9, 0, 7, 5, 0, 2, 6, 0 from front to rear. What are the contents of queue Q2 from front to rear after the execution of following function.

```
void Dosomething ( )
{   int x,y,z;
    while(!emptyQ(Q1))
    {
        dequeue(Q1, x);
        if(x equals 0)
        {
            z = 0;
            while(!emptystack(s))
            {
                popstack(s,y);
                z += y;
            }
            enqueue(Q2, z);
        }
        else
        pushstack(s,x);
    }
}
```

(a) 15, 12, 8 (b) 8, 12, 15
(c) 20, 12, 8 (d) 8, 12, 20

09. A stack is implemented with two queues then what are the minimum enqueue and dequeue operations needed to perform for pop operation where n is the number of elements already in the first queue.
(a) 3n + 1, 2n – 1
(b) 2n – 2, 2n – 1
(c) 2n, 2n + 1
(d) 2n – 2, 3n – 3

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10. Recursive definition of multiplication is as follows

$$a * b = \begin{cases} a & \text{if } b = 1 \\ a * (b-1) + a & \text{if } b > 1 \end{cases}$$

How many times this recursive multiplication will be called for multiplying 9 * 4?

(a) 5 (b) 3
(c) 4 (d) none

11. The infix expression A – (B+C) * (D/E) is equivalent to which of the following postfix expression

(a) ABC+ – DE*/ (b) ABC+DE/*–
(c) ABC + * DE / – (d) ABC + D /*E –

12. Consider the following function

```
int x (int n)
{
    if (n < 3)
    return 1;
    else
    return x (n – 1) + x (n – 3) +1;
}
```

How many times the function is involved for calculating x (x (x (3)))

(a) 17 (b) 9
(c) 10 (d) 15

Common Data for Q13 & Q14

Consider the following function:

$$fib(n) = \begin{cases} 0 & n = 0 \\ 1 & n = 1 \\ fib(n-1) + fib(n-2) & n > 1 \end{cases}$$

13. How many invocations are there for evaluating fib (9)?

(a) 100 (b) 103
(c) 105 (d) 109

14. How many additions are taking place for the evaluation of fib (7)?

(a) 15 (b) 20
(c) 25 (d) 35

15. A circular queue of characters is implemented using a linear array [1..6]. The array currently contain array [d, -, -, a, b, c], if one is deleted and two are added, what would be the positions of rear and front pointers?

(a) 6, 1 (b) 4, 3
(c) 5, 3 (d) 3, 5

16. The postfix expression of prefix *+ab–cd is

(a) ab+cd–* (b) ab+cd*–
(c) abcd+–* (d) ab+–cd*

17. Consider the following pseudo code:

```
Algorithm  hello( n is integer)
{
    if (n is 1)
            return 1;
    else
            return 1/n + hello(n – 1);
}
```

This algorithm is used to add the series

(a) 1+ 1/2! +1/3! ...
(b) 1 + 1/2 +1/3 ...
(c) 1+2+3+.....
(d) 1/ 2+1/3 +...

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18. Consider the following nested recursion

$$h(n)=\begin{cases} 0 & \text{if } n=0 \\ n & \text{if } n>4 \\ h(2+h(2n)) & \text{if } n\le 4 \end{cases}$$

What is the value of h(2) ?

(a) 8 (b) 12
(c) 16 (d) 22

19. What is the prefix of the following infix expression:

(log x) + (log y)

(a) + log x log y (b) + x log y log
(c) x log + y log (d) + log log x y

20.
```
void Nontail(int x)
{
    if(x>0)
    {
        Nontail(x-2);
        printf("%d",x);
        Nontail(x-1);
    }
}
```

What is the output if the invocation is Nontail(5)?

(a) 32152141321 (b) 1321141321
(c) 132151321 (d) 132152141321

21. Consider the following expression with A, B, C as operators 2 B3A 4 C 5 A 6. Assume the precedence rules as

i. A is having higher precedence over B and C
ii. B and C are right associative

Find the **postfix** equivalent expression

(a) 2 A B 3 C 4 5 6
(b) B C B 2 3 4 A 5 6
(c) 2 3 4 A 5 6 A C B
(d) 2 3 4 A B 5 6 A C

22. The prefix expression of (A+ B) * C – D/E is

(a) – * + ABC/DE (b) – + * ABC/DE
(c) +* ABC–/DE (d) + – * ABC/DE

23. Match the following:

Data structure	used for
P: Stack	1. Symbol table
Q: Queue	2. Event driven simulation
R: Hashing	3. Jobs sent to a printer
S: Priority Queue	4. Check for balanced parenthesis

(a) P – 4, Q – 2, R – 1, S – 3
(b) P – 4, Q – 3, R – 1, S – 2
(c) P – 3, Q – 4, R – 1, S – 2
(d) P – 4, Q – 3, R – 2, S – 1

24. Consider the following algorithm to reverse the contents of the stack.

Stack: original stack
temp1 and temp 2 are the temporary stacks
algorithm reversestack
loop (stack.pop(data))
    temp1.push(data)
end loop
loop (temp1.pop(data))
    temp2.push(data)
end loop
loop (***blank***)
    stack.push(data)
end loop
end of the algorithm

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Fill up the ***blank*** with the appropriate option.

(a) temp1.push(data) (b) temp1.pop(data)

(c) temp2.push(data) (d) temp2.pop(data)

25. Consider the following code:

```
int x(int n)
{
    if ( n > 0)
            return (x(n–1) + x(n–1));
    else
            return(1);
}
```

Assume the value of n >= 0, then the above code is best suitable for finding out:

(a) x^n (b) $2x^n$

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

26. Consider the following algorithm:

```
Algorithm Queueoperation (model:queue)
queuesize = CountQueue(queue)
count = 0
loop (count < queuesize)
        dequeue (queue, queueData)
        if (queueData >= 0 )
            enqueue (queue, queueData)
        endif
    count++
end loop
stop.
```

What does this algorithm do?

(a) Deletes all positive integers and the order of the elements in the queue are changed.

(b) Deletes all positive integers without changing the order of the elements in the queue are changed.

(c) Deletes all negative integers and the order of the elements in the queue are changed.

(d) Deletes all negative integers without changing the order of the elements in the queue.

27. The expression for the infix equivalent of the postfix form 1, 2, +, 3, *, 4, 5, *, – will be

(a) 1 + 2 * 3 – 4 * 5

(b) (1 + 2) * (3 – 4) * 5

(c) (1 + 2) * 3 – (4 * 5)

(d) 1 + 2 * (3 – 4) *5

28. The following sequence of operations is performed on a stack. Push (10), Push (10), Push (20), POP, Push (20), PoP, PoP, PoP, Push(10), PoP. The sequence of values PoPed out is

(a) 20, 10, 10, 20, 20

(b) 20, 20, 10, 10, 10

(c) 10, 10, 20, 20, 20

(d) 10, 20, 20, 20, 20

29. What is the value of the postfix expression –, *, +, 2, 3, 4, –, 5, 6

(a) 19 (b) 21

(c) 20 (d) –2

30. In a stack, (size of 1 to n) the command to access i^{th} element from the top of the stack S will be known as Peep (S, i). What is the condition to check for underflow on Peep

(a) S [Top – i] ≤ 0 (b) S[Top+i] ≤ 0

(c) S[Top – i+1] ≤ 0 (d) None

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31. Stack A has the entries a, b, c (with a on top). Stack B is empty. An entry popped out of stack A can be printed immediately or pushed to stack B. An entry popped out of the stack B can only be printed. In this arrangement, which of the following permutations of a, b, c are ***not*** possible?

(a) b a c (b) c b a
(c) c a b (d) a b c

32. Consider the algorithm for reversing stack contents in-place.

Let stack be the data structure with push, pop and count function.

And consider the Algorithm

```
Algorithm reverse (stack st)
{
        int m = st.pop();
        if(st.count ! = 1)
        reverse(st);
        Do(st,m);
}
Algorithm Do(stack st, int a)
{
        int x = st.pop();
        if (st.count ! = 0)
        Do(st, a);
        else
        _____;
        st.push(x);
}
```

What is the blank in above 'Do' algorithm?

(a) Do(st,x) (b) Do(st+1,x)
(c) st.push(a) (d) st.pop(a)

33. _____ is the number of moves of the smallest disc in Towers of Hanoi implementation where the tower consisting of 17 discs (numbered from 0 to 16)

34. Which of the following stack permutations **CANNOT** be obtained for the input sequence 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

(a) 3, 4, 5, 2, 1, 6, 7, 8, 9, 10, 12, 11
(b) 4, 3, 5, 6, 2, 1, 8, 7, 10, 9, 11, 12
(c) 1, 2, 3, 5, 6, 4, 12, 11, 10, 9, 8, 7
(d) 2, 5, 6, 3, 4, 1, 7, 8, 9, 12, 10, 11

35. Choose incorrect statement from the options given below?

(a) a stack and queue can be implemented in a single array v[1.....m].
(b) 'n' circular queues can be implemented in a single array v[1...m], (m>>n)
(c) n_1 stacks and $n_2 = n - n_1$ queues can be implemented in an array v[1...m], (m>>n)
(d) none of the above

Common Data for Q36 and Q37

If the following recurrence relation, is used

$C(n, 0) = 1$ and $C(n, n) = 1$ for $n \geq 0$

$C(n, k) = C(n-1,k) + C(n-1, k-1)$ for $n > k > 0$

36. What is the value of C (6,4)?

(a) 5 (b) 10
(c) 15 (d) 20

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37. How many times the addition (+) is called for computing C(6, 4)?

(a) 14 (b) 19
(c) 9 (d) 12

Common Data for Q38 and Q39

Suppose that you are a financier and purchase 100 shares of stock in company X in each of Jan, April, September and sell 100 shares in each of June and November. The prices per share in these months were

Jan	April	June	September	November
Rs 10	Rs 30	Rs 20	Rs 50	Rs 30

38. Determine the total amount of your capital gain or loss using Stack (LIFO accounting)

(a) Loss 3000 (b) Profit 1000
(c) Loss 1000 (d) Profit 3000

39. Repeat the above with Queue (FIFO accounting)

(a) Loss 3000 (b) Profit 1000
(c) Loss 1000 (d) Profit 3000

Note: The 100 shares you still own at the end of the year do not enter the calculations.

40. Consider the following function

```
void quiz (int N)
{
        if (N > 1)
        {       quiz (N/2 );
                quiz(N/2 );
        }
        printf( " * ");
}
```

How many asterisks are printed by the function call quiz(5) ?

(a) 3 (b) 4
(c) 7 (d) 8

41. Translate the following prefix form into postfix form:

Prefix: and < x y or not = + x y z > x 0

(a) x y < x y + z = not x 0 > or and
(b) x y < and x + y = z not x 0 > or
(c) x y + z = not x y < and x 0 > or
(d) x y < x y + z = x 0 > or not and

42. Which of the following statements are correct?

i. A stack may be viewed as descending priority queue.
ii. A queue may be viewed as descending priority queue.
iii. A queue may be viewed as ascending priority queue.
iv. A stack may be viewed as ascending priority queue.

(a) i, ii (b) i, iii
(c) ii, iv (d) iii, iv

43. Convert the given infix form to postfix form

x = (@ b + (b↑2 – 4 *a*c)↑ 1/2) / (2*a)

(a) x b @ b 2 ↑ 4 a c* * – 1/2 ↑ + 2 a * / =
(b) x b @ b + 2 ↑ 4 a * c * –1/2 ↑2 a * / =
(c) x b @ b 2 ↑ 4 a * c * – 1/2 ↑ 2 a * / + =
(d) x b @ b 2 ↑ 4 a *c * – 1/2 ↑ + 2 a * / =

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44. For the linked list implementation of the stack, where are the pushes and pops performed?
(a) Push in front of the first element, pop the first element
(b) Push after the last element, pop the last element
(c) Push in front of the first element, pop the last element
(d) Push after the first element, pop the first element

45. If the expression ((2 *3)+ 4 * 5 +(6*7)+8)*9 is evaluated with + having precedence over *, then the value obtained is the same as the value of the following prefix expression?
(a) + + * + 2 3 4 *.* 5 + 6 7 8 9
(b) + * + + 2 3 4 * * 5 + 6 7 8 9
(c) * * + * 2 3 4 + + 5 * 6 7 8 9
(d) * + + + 2 3 4 * * 5 + 6 7 8 9

46. Consider the following algorithm to reverse contents of stack:

S → original stack

t_1 and t_2 → Temporary Stacks

```
Algorithm Reverse stack:
    loop (s.pop(data))
            temp1.push(data)
    end loop
    loop( _____ )
            temp2.push(data)
    end loop
    loop (temp2.pop(data))
            s.push(data)
    end loop
end of algorithm
```

Fill up the blank with appropriate option.
(a) temp1.pop(data)
(b) temp2.pop(data)
(c) temp2.push(data)
(d) temp2.push(data)

47. The result of the postfix expression
5 3 * 9 + 6 / 8 4 / + is
(a) 6
(b) 7
(c) 8
(d) 9

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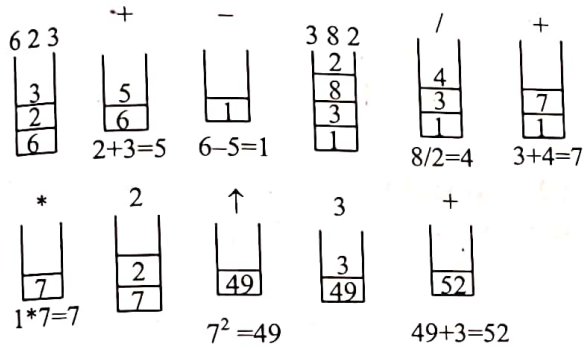
Solutions

01. Ans: (b)

Sol: If operand push into stack, if operator pop the top two elements then push the result.



02. Ans: (c)

Sol: Permutation of n numbers. It is stack application.

03. Ans: (c)

Sol: Checks whether queue is non-empty or not. If non-empty then delete the element from queue until queue becomes empty then insert the last deleted element first and continue this process. At the end we get reversed elements in queue.

04. Ans: (c)

Sol: Using rule A: $3-2*4\uparrow 1*2\uparrow 3$

$1*4\uparrow 1*2\uparrow 3$

$4\uparrow 2\uparrow 3$

$4^2\uparrow 3$

$16^3 = 2^{12}$

Using rule B: $3-2*4\uparrow 1*2\uparrow 3$

$1*4\uparrow 1*2\uparrow 3$

$4\uparrow 2\uparrow 3$

$4\uparrow 2^3 = 4\uparrow 8 = 4^8 = 2^{16}$

Using rule C: $3-2*4\uparrow 1*2\uparrow 3$

$3-8\uparrow 1*2\uparrow 3$

$3-8*2\uparrow 3$

$3-16\uparrow 3$

$3-16^3$

$3-2^{12}$

$C < A < B$

05. Ans: (c)

Sol: First move after n + 1 calls, for n = 50, first move is 51

Total moves $= 2^n - 1$

$= 2^5 - 1 = 31$

Total calls $= 2^{n+1} - 1$

$= 2^7 - 1 = 127$

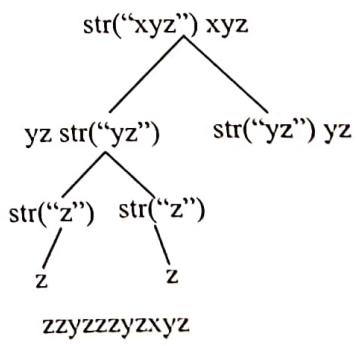
Last move = after total calls – 1

$= 2^6 - 1 = 63$

Last move after 62 calls

06. Ans: (c)

Sol:



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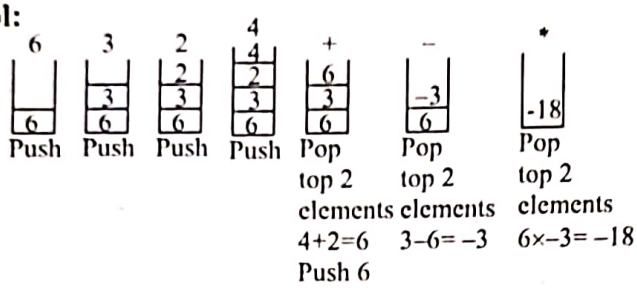
07. Ans: (a)

Sol:



Answer = – 18.

It is between –15 and – 100.

08. Ans: (c)

Sol: Queue Q_1

5	6	9	0	7	5	0	2	6	0

front rear

x = dequeue (Q_1) = 5

Push 5

$5 \neq 0$

x = dequeue (Q_1) = 6, $6 \neq 0$

push 6

x = dequeue(Q_1) = 9, $9 \neq 0$

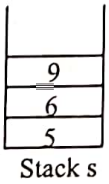
push 9

x = dequeue(Q_1) = 0 == 0

z = 0 pop y = 9

z = 9

pop y = 6



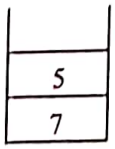
Q_2

20	12	8

z = 15

pop y = 5

z = 20



Now s is empty

x = dequeue (Q_1) = $7 \neq 0$ push

x = dequeue (Q_1) = $5 \neq 0$ push

x = 0, z =0 pop y = 5

pop y =7

z = 12

x = 2 push

x = 6 push

z = 0 pop y = 6

z = 6

pop y = 2

z = 8

09. Ans: (b)

Sol: Assume Q_1 has 3 elements

5	4	6

From stack point of view pop outputs 6

Using extra queue Q_2. We perform pop operation.

Sequence of operations are

dequeue(q_1) enqueue(q_2)

dequeue(q_1) enqueue(q_2)

dequeue(q_2) enqueue(q_1)

dequeue(q_2) enqueue(q_1)

dequeue(q_1)

2n – 2 enqueue, 2n–1 dequeue

10. Ans: (c)

Sol: call 1 → 9 × 4

call 2 → 9 × 3

call 3 → 9 × 2

call 4 → 9 × 1

11. Ans: (b)

Sol: Infix expression ⇒ A –(B + C) * (D/E)

Postfix ⇒ A –(BC+) * (DE/)

⇒ A –(BC+DE/*)

⇒ ABC+DE/*–

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12. Ans: (b)

Sol: x(3) 3

x(2) + x(0) +1

|| ||

1 1

9 times

x(x(3)) = x(3)=3

x(2) + x(0)+1

x(x(x(3))) = x(3)

13. Ans: (d)

Sol: Number of calls for evaluating

f(n) = 2 * f(n + 1) – 1

Number of additions = f(n + 1) – 1

Number of calls for evaluating

f(9) = 2 * f(10) –1

= 2 * 55 –1

= 109

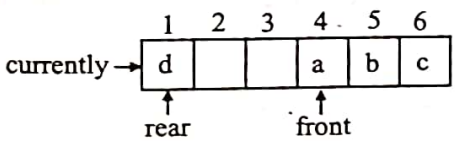
14. Ans: (b)

Sol: Number of additions for fib(7) = fib(8) –1

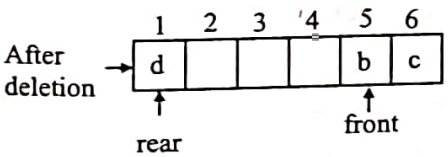
= 21 – 1 = 20

15. Ans: (d)

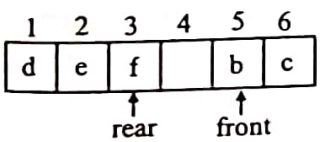
Sol:



One deletion → the circular queue becomes



After addition of two elements



Position of rear = 3

Position of front = 5

16. Ans: (a)

Sol: The Prefix expression is * + ab – cd

Equivalent Infix expression = (a+b) * (c–d)

⇒ Postfix expression is (ab+) * (cd–)

ab+cd–*

17. Ans: (b)

Sol: It prints $= \frac{1}{n} + \frac{1}{n-1} + \frac{1}{n-2} + \ldots\ldots = \frac{1}{2} + 1$

18. Ans: (b)

Sol: h(n) = h(2 + h(2n))

h(2) = h(2+h(4))

h(4) = h(2 + h(8))

= h(2 + 8) = 10

h(2) = h(2 + h(4))

= h(12)

= 12

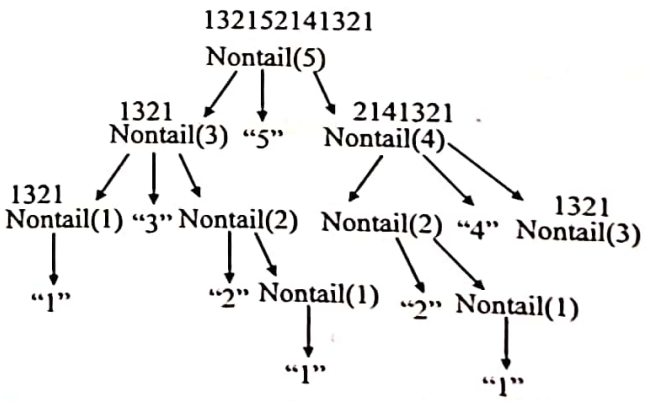
19. Ans: (a)

Sol: (log x) + (log y)

+ logx logy

20. Ans: (d)

Sol:



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21. Ans: (d)

Sol: Infix: 2 B 3A 4 C 5A 6

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

Postfix: 2 3 4 A B 5 6 A C

22. Ans: (a)

Sol: Infix = (A + B) * C –D/E

Prefix = (+AB) * C – D/E

*(+ABC) – (/DE)

–*+ABC/DE

23. Ans: (b)

Sol: Stack → checking for balanced parenthesis

Queue → Jobs sent to the printer

Hashing → Symbol table

Priority Queue → Event driven

24. Ans: (d)

Sol: First POP the elements from the original stack. PUSH them into temporary stack temp1.

Second POP the elements from the temp1 stack and PUSH them into another temporary stack temp2.

Third POP the elements from the temp2 stack and PUSH them into original stack.

25. Ans: (c)

Sol: To calculate 2^n, we use recursion

when n = 0 → 1

when n = 1 → 1 + 1 = 2

when n = 2 → 2 + 2 = 2^2

when n = 3 → $2^2 + 2^2 = 2^3$

when n = 4 → $2^3 + 2^3 = 2^4$

26. Ans: (d)

Sol: It delete all –ve elements, without changing the order of the elements in the queue.

27. Ans: (c)

Sol: Postfix: 1, 2, +, 3, *, 4, 5, * ,–

(1 + 2), 3, *, 4, 5, *, –

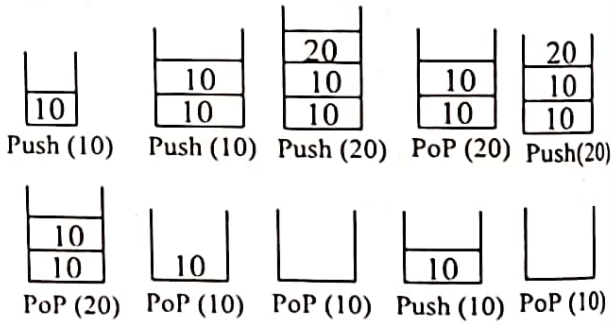
((1 + 2)*3), 4, 5*–

((1+2)*3), (4*5)–

((1+2)*3) – (4*5)

28. Ans: (b)

Sol:



Popped out Q = 20, 20, 10, 10, 10.

29. Ans: (b)

Sol: (2+3) * 4 – (5–6)

(5 * 4) + 1 = 20 + 1 = 21

30. Ans: (c)

Sol: Algorithm Peep (S, i)

peep (S, 4)

if((?) ≤ 0)

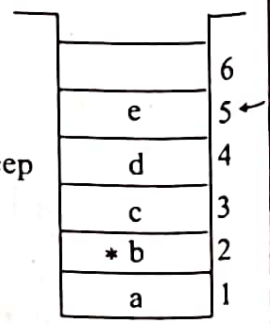
Top – i + 1

Stack is underflow on peep

5 – 4 + 1

exit (1)

return S[Top–i+1]



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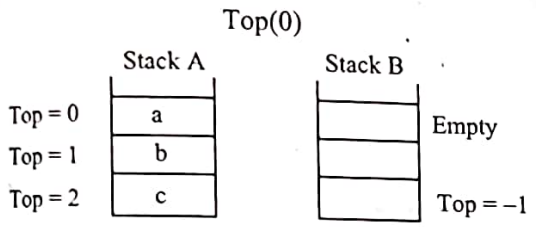
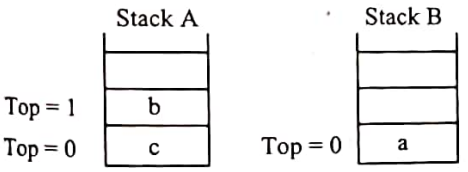
31. Ans: (c)

Sol:



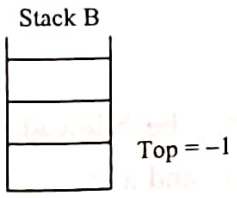
After stack A is poped (LIFO).

Pushed into stack B.



Print stack A ⇒ cb

Poped the element into the stack B



Poped element stack B = a

The stack is empty

Print stack A & B ⇒ c b a

32. Ans: (c)

Sol: After traversing all elements in the stack, we push the elements so that the order will be reversed. So, the blank implements pushing of elements into the stack.

33. Ans: 65536

Sol: $2^{16} = 65536$

34. Ans: (d)

Sol: (a) 3, 4, 5, 2, 1, 6, 7, 8 ,9,10, 12,11 ⇒ valid

(b) 4, 3, 5, 6, 2, 1, 8, 7 ,10,9, 11,12 ⇒ valid

(c) 1, 2, 3, 5, 6, 4, 12,11, 10,9, 7, 8 ⇒ valid

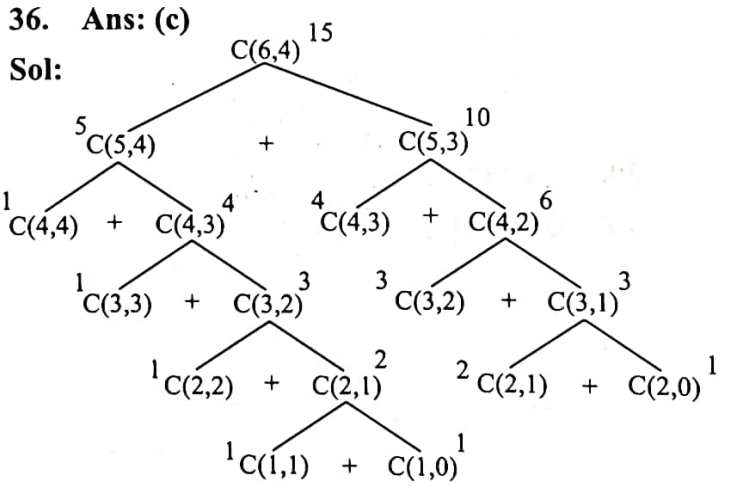
(d) 2, 5, 6, 3, 4, 1, 7, 8, 9, 10 ⇒ Invalid because '3' can not be popped out ahead of '4'.

35. Ans:(c)

Sol: n_1 stacks and $n_2 = n - n_1$ queues can not be possible to implement in an array v[1….m] , m > n

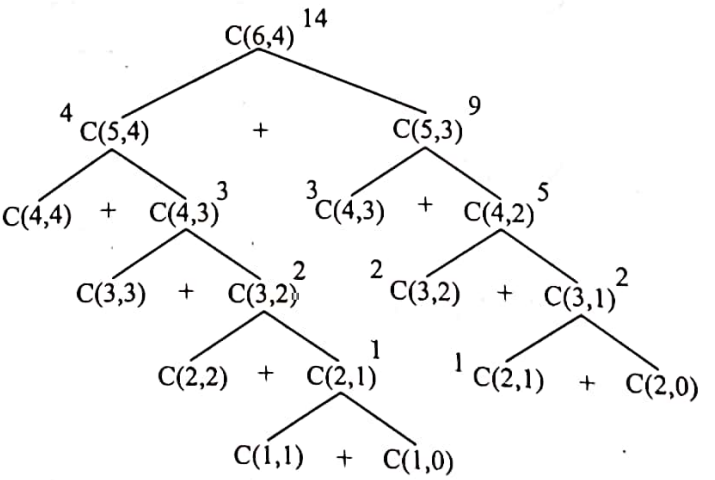
36. Ans: (c)

Sol:



37. Ans: (a)

Sol: Number of additions



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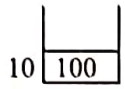
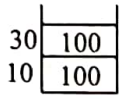
38. Ans: (a)

Sol: Jan 100 shares each 10

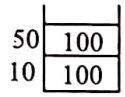


April 100 shares each 30



June sell 100 each 20 loss is 1000

Sept buy 100 shares each 50

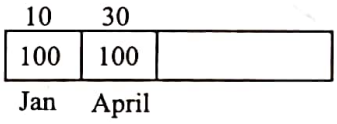


Nov sell 100 shares each 30 loss 2000

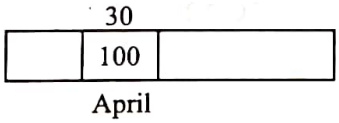
∴ Total loss = 3000

39. Ans: (b)

Sol: Queue Buy

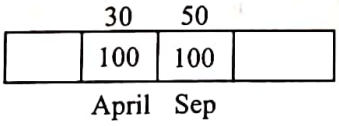


June sell

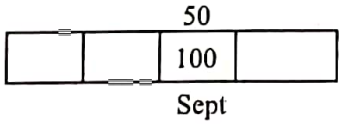


Profit 1000

Sept Buy



Nov Sell

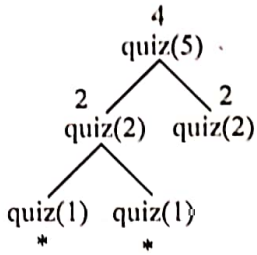


Profit or loss = 0

∴ Total profit = 1000

40. Ans: (b)

Sol:



4 asterisks are printed

41. Ans: (a)

Sol: Prefix ⇒ and < xy or not = + x y z > x 0

and (x < y) or not = + x y z > x 0

and (x < y) or not = (x+y)z (x> 0)

and (x < y) or ((x+y) not =z) (x > 0)

Infix → (x<y) and (((x+y) not =z) or (x > 0))

Postfix→(xy<) and (((xy+) not=z) or (x0 >))

(xy<) and ((xy+z = not) or (x0 >))

(xy<) and (xy+z = not x0 > or)

xy < xy + z = not x 0 > or and

42. Ans: (c)

Sol: A queue can be viewed as descending priority queue and a stack can be viewed as ascending priority queue.

43. Ans: (d)

Sol: Infix to Postfix

x = (@ b + (b ↑ 2 – 4 * a * c) ↑ 1/2) / (2 * a)

x = (@ b + (b 2 ↑ – 4 a * c *) ↑ 1/2) / (2a *)

x = (@ b + (b 2 ↑ 4 a * c * –) ↑ 1/2) / (2 a*)

x = (@ b + (b 2 ↑ 4 a * c * – 1/2 ↑)) / (2 a*)

x = b @ b 2 ↑ 4 a* c * – 1/2 ↑ + 2a*/

x b @ b 2 ↑ 4 a * c * – 1/2 ↑+ 2 a*/=

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44. **Ans: (a)**

Sol: Push and Pop are implemented at the beginning of the linked list (LIFO).

45. **Ans: (c)**

Sol: Infix expression: ((2*3)+4*5+(6 * 7) + 8)*9

Prefix: + having precedence over *

((*23) + 4 * 5 + (*67) +8) *9

((+*234) * (+5 * 67) + 8) * 9

(+*234) * (+ +5 * 678) * 9

* * + * 2 3 4 + + 5 * 6 7 8 9

46. **Ans: (a)**

Sol: After pushing data into temp1, we take that data and push it in temp2. So, the blank performs popping of data from temp1.

47. **Ans: (a)**

Sol: The infix expression will be:

(5*3+9) / 6 + (8/4) = 4 + 2 = 6

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Chapter 3 Linked Lists

01. Which of the following represents the minimum order of time required to interchange the mth and n^{th} elements of a singly linked list?

(a) max(m, n) (b) min(m,n)

(c) m + n (d) m+ min(m, n)

02. In a doubly linked list pointed by head node, a pointer 'p' points to an arbitrary element in the middle of the list. Which of the following sets of operations would correctly insert a new node, pointed to by pointer 'n' to the right of 'p'?

(a) n → right = p → right;
n → left = p;
p → right = n;
n → right →left = n;

(b) n → left = p;
p → right = n;
n → right = p → right;
p → right → right = n;

(c) n → right = p → right
n → left = p → left;
n → right → left = p;
p → right = n;

(d) more than one of the above

03. You are having a pointer to the head of singly linked list. The list either terminates at null pointer or it loops back to some previous location (not necessarily to the head of the list).

What is the time complexity of best algorithm to find whether the list loops back or ends at a null location?

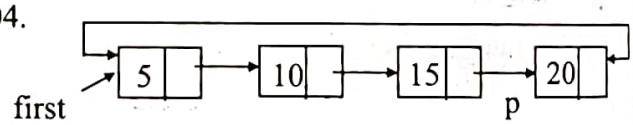
(a) there exist no algorithm

(b) It is the time proportional to the length of the list

(c) O(1)

(d) algorithm exist but it finds only whether the list end with null pointer and loops infinitely if the pointer loops back to some previous location

04.

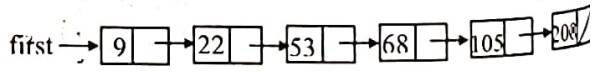


What is the value of p → next → next?

(a) 5 (b) 10

(c)15 (d) none of the above

05. What would be the output of the following after executing the sequence of operations?



struct node * p

i) p = first → link;

ii) first → link = p → link → link → link;

iii) first → link → link → link = p;

v) print("%d",p→link→link→link→link→link→data);

(a) 9 (b) 22

(c) 53 (d) 68

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06. Match the following:

How many link fields get updated in doubly linked list?

Operation	No. of updations
P: inserting a node else where in the middle	1. 1
Q: inserting a node right most	2. 2
R: deleting a node else where in the middle	3. 3
S: deleting a node right most	4. 4

(a) P–3, Q–4, R–2, S–1
(b) P–4, Q–3, R–2, S–1
(c) P–3, Q–4, R–1, S–2
(d) P–3, Q–2, R–4, S–1

07. What will be the following function do on a given linked list?

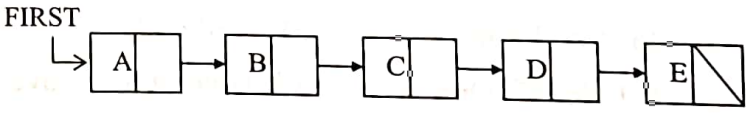
```
void ABC (struct node** headRef)
{
        struct node* first;
        struct node* rest;
        if (*headRef == NULL) return;
        first = *headRef;
        rest = first → next;
        if (rest == NULL) return;
        ABC (&rest);
        first → next → next = first;
        first → next = NULL;
        *headRef = rest;
}
```

(a) Reversing a linked list.
(b) Converting to circular linked list.
(c) Converting a given singly linked list to have alternate nodes of singly linked list.
(d) Converting a given singly linked list to have alternate nodes of circular linked list.

08. Which of the following is not efficiently supported by a singly linked list?

(a) accessing the element in the current position
(b) insertion after the current position
(c) insertion before the current position
(d) moving to the position immediately following the current position

09.



The following sequence of operations are performed on the above singly linked list

struct node * P;

i. P = First → link → link;
ii. P → link → link → link = First;
iii. P = P → link → link;
iv. printf ("%c", P → data);

(a) E
(b) D
(c) C
(d) B

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10. Consider the following routine and fill up the blank:

```
struct node * first (struct node * head)
{
    if (          ?          )
    {
        struct node * current = head;
        struct node * new = (struct node*)
                malloc (sizeof (struct node));
        new → data = current → data;
        new → next = first (current→next);
        return (new);
    }
}
```

(a) ! head (b) head
(c) head→next (d) ! head→next

11. The nth node in a singly linked list is accessed via where (n > 1)?

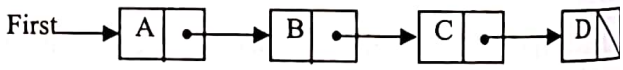
(a) Head node (b) Tail node
(c) $(n-1)^{th}$ node (d) none of the above

12. What does the following program do on two lists?

```
struct node* do (struct node* a, struct node* b)
{
    struct node* result = NULL;
    if ( a == NULL) return (b);
    else if (b == NULL) return (a);
    if (a → data <= b→data)
    {
        result = a;
        result → next = do (a→next, b);
    }
    else
    {
        result = b;
        result →next = do (a, b→next);
    }
    return (result);
}
```

(a) merge two sorted linked lists
(b) merge two unsorted linked lists
(c) merge two linked lists by choosing alternate nodes
(d) merge two linked lists by choosing the nodes in reverse

13. Here is the code for this single linked list:




```
void Do (struct node * beforep)
{
    struct node *p, * afterp;
    p = beforep → next;
    afterp = p → next ;
    p→ next = afterp→ next;
    beforep→ next = afterp;
    afterp→ next = p;
}
```

What is the output after invoking Do(first)?

(a) D C B A (b) D B C A
(c) A C B D (d) B A C D

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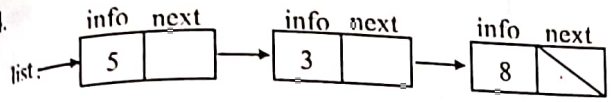
14. 

for above given linked list.

Consider the following sequence of operation

```
P = getnode()
info (P) = 6;
next (P) = list;
list =P;
  :
P = list;
list = next (P);
X = info (P);
Freenode(P);
```

The above sequence of operation to linked list results into

(a) Updation of a node in arrays
(b) Deletion of a node
(c) Linked list remains the same
(d) None of the above

15. Here is the iterative list reverse. Find the missing parameter.

```
static void Reverse(struct node** headRef)
{
    struct node* result = NULL;
    struct node* current = *headRef;
    struct node* next;
    while (current != NULL)
    {
        next = current→next;
        current→next = result;
        result = current;
        current = next;
    }
    *headRef = ?;
}
```

(a) null (b) result
(c) current (d) next

16. void Do(struct node * p)

```
{
    if(!p)
    return;
    Do(p → next);
    printf("%d", p →data);
    return;
}
```

What does this routine do on singly linked list?

(a) Display the elements.
(b) Display the elements in the reverse and the list is unchanged.
(c) Display the elements in the reverse and the list is changed to reverse.
(d) None of the above.

17. Consider the following algorithm:

Algorithm What_am_I_doing(plist is head pointer)

```
1 pwalk = plist
2 loop ( pwalk not to null)
    1 if ( pwalk→key < 0 AND pwalk→link
      not null)
    1 deletenode(plist, pwalk, pwalk→link,
      dataout)
    2 end if
    3 pwalk = pwalk→link
3 end loop
return (plist not equal null)
end of the algorithm.
```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In the above algorithm deletenode( ) function is being used whose functionality given below:

DELETENODE (1arg, 2arg, 3arg, 4arg)
1arg is a pointer to a valid list.
2arg is a pointer to predecessor node.
3arg is a pointer to node to be deleted and.
4arg is address to pass deleted data to calling module.

What does the above algorithm do on a singly linked list?

(a) Deletes all nodes whose keys are negative.
(b) Deletes all nodes that are after a node with a negative key.
(c) Deletes any node that is before a node with a negative key.
(d) Deletes all nodes that are before a node with a negative key.

18. Here is the code on linked lists:

```
//error checks are emitted for clarity
void Do (struct node *bp)
{        struct node *p, *ap;
         p = bp → next;
         ap = p → next;
         p → next = ap → next;
         bp → next = ap;
         ap → next = p;
}
```

The above routine *swap* two adjacent elements.

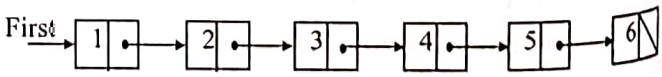
(a) By adjusting only the links in singly linked lists.
(b) By adjusting only the data in singly linked lists.
(c) By adjusting only the links in doubly linked lists.
(d) By adjusting only the data in doubly linked lists.

19. Consider the following code on a singly linked list

```
int k;
for (p=Head;k=2;p!=0&&k<i;p=p→next; k++);
if (p!=0 && p→ next!=0)
{
    tmp = P → next ;
    p → next = p →next → next ;
    delete tmp;
}
```

The above routine
(a) deletes i^{th} node
(b) deletes the predecessor of ith node
(c) deletes the successor of ith node
(d) List remains intact.

20.



What is the output after the following sequence of steps?

Struct Node *P;
(i) P=First →link→link→link→link;
(ii) P→ link→link = First→ link→link;
(iii)First→link=P→link;

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(iv) printf("%d", P→ data);

(v) printf("%d",First→link→link→link→link → data);

(vi) printf("%d",P→link→link→link→link →data);

(a) 1, 2, 3 (b) 3, 4, 5

(c) 5, 6, 1 (d) 5, 5, 5

1. I have implemented the queue with a linked list, keeping track of a front pointer and a rear pointer. Which of these pointers will change during an insertion into an EMPTY queue?

(a) neither changes

(b) Only front_ptr changes

(c) Only rear_ptr changes

(d) Both changes

2. Here is the recursive version of CopyList().

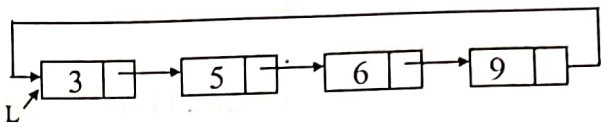
```
// Recursive copy list
struct node* CopyList(struct node* head)
{
    if ( ?)
    return NULL;
    else {
    struct node* newList = malloc(sizeof(struct node));
                    // make the one node
    newList→ data= current →data;
    newList→next = CopyList (current → next);
    // recur for the rest

    return (newList);
    }
}
```

(a) !head (b) head

(c) !head → next (d) head→next

23.




```
int find (struct node *L, int k)
{
        while (L→data ! = k)
        L = L→next;
        if (L→ data ==k)
        return (1);
        else return (–1);
}
```

In the above segment if the value of k is 5, then the function returns 1 whereas if the value of k is 8 then what does it do?

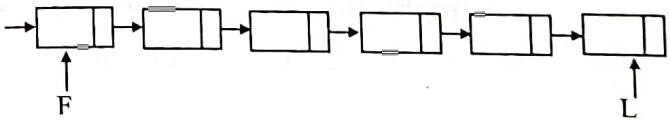
(a) return (–1)

(b) goes to infinite loop

(c) give garbage value

(d) none

24. Consider a singly linked list of the form:



Where 'F' is a pointer to the first element in the list and 'L' is a pointer to the last element in the list. The time of which of the following operations depends on the length of the list?

(a) Delete the last element of the list

(b) Delete the first element of the list

(c) Add an element after the last element of the list

(d) Add an element before the first element of the list

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25. Match the following:

Data Structure

P: Implementation of linked lists in arrays

Q: Linked lists

R: Graphs

S: Stack & Queue

Suitable / not suitable

1) Not suited to random access
2) Not possible of insertion and deletion any where in the list.
3) Suited to networks
4) Suitable where dynamic memory allocation not possible.

Codes:

(a) P – 4, Q – 2, R – 1, S – 3

(b) P – 4, Q – 3, R – 1, S – 2

(c) P – 3, Q – 4, R – 1, S – 2

(d) P – 4, Q – 1, R – 3, S – 2

26. Consider the following recursive routine to reverse a singly linked list, in which first is a pointer pointing to the very first node.

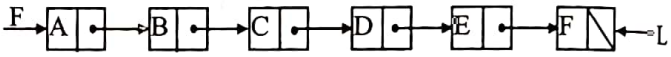
```
void Do (struct Node * P, struct Node * C)
{
    if (C)
    {
            Do(C, C → link) ;
            C → link = P;
    }
    else
            First = P;
}
```

What is the invocation from the main ( ) routine?

(a) Do(first, Null) (b) Do (First, First)

(c) Do (Null, First) (d) Do (Null, Null)

27. Consider a singly linked list of the form



Where F is a pointer to the first element in the list.

L is a pointer to the Last element in the list.

Which of the following is (are) true for the operation where the entire list NEED NOT be traversed?

I. Delete the last element

II. Delete the first element

III. Append a node after last element

IV. Insert a node ahead of the first element

(a) I only

(b) I and III only

(c) II and III only

(d)II, III ,IV

28. Which of the following operations is performed more efficiently by doubly linked list than by linear linked list?

(a) Deleting a node whose location is given

(b) Searching an unsorted list of a given item

(c) inserting a node after the node with a given location

(d) Traversing the list to process each node.

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29. Node * do (Node * node, int n)

```
{
    Node* pointer1 = node;
    Node* pointer2 = node;
    while(pointer1  != null && n>0)
    {
        pointer1 = pointer1 → next;
        n – –;
    }
    if (n > 0)
        return null;
    while (pointer1 != null)
    {
        pointer1 = pointer1→ next;
        pointer 2 = pointer2 → next;
    }
    return pointer2;
}
```

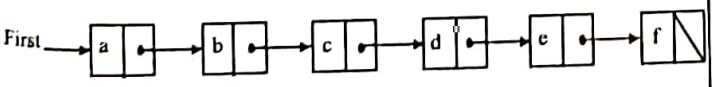
(a) To find minimum element from the linked list

(b) To find maximum element from the linked list

(c) To find n^{th} element from the beginning of the linked list

(d) To find n^{th} element from the end of the linked list

30. What is the output after the following sequence of steps?



struct node *p;

(i) p = first → link → link → link;

(ii) p → link → link →link = first;

(iii)first → link → link = p→ link → link;

(iv)printf("%c", first → link → link→ link →link → data);

(a) a (b) b (c) c (d) d

31. Consider the linked list representation of a circular queue.

After the step: **Rear → link = new node();**

Where front, rear are pointers to front and rear ends of the queue and node is a structure with data and link parts.

Which is the next step for inserting element 'x'.

(a) rear → link → data = x;
rear → link → link= null;
rear = rear → link;

(b) rear → link → data = x;
rear = rear → link;
rear → link = null;

(c) rear → link → data = x;
rear → link → link= front;
rear = rear → link;

(d) rear → link → data = x;
rear → link = front;
rear = rear → link;

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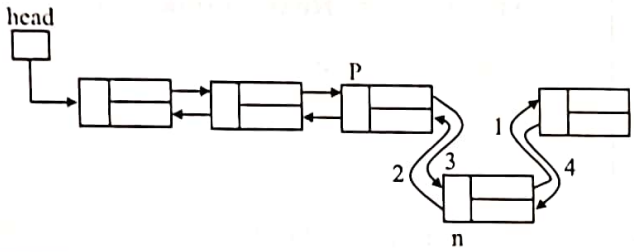
Solutions

01. Ans: (a)

Sol: To interchange m^{th} and n^{th} elements of a single linked list, first the position of mth and n^{th} elements must be searched. To search it takes max(m, n) time. Then the elements can be exchanged.

02. Ans: (a)

Sol:



1. n → right = p → right;
2. n → left = p;
3. p → right = n;
4. n → right → left = n;

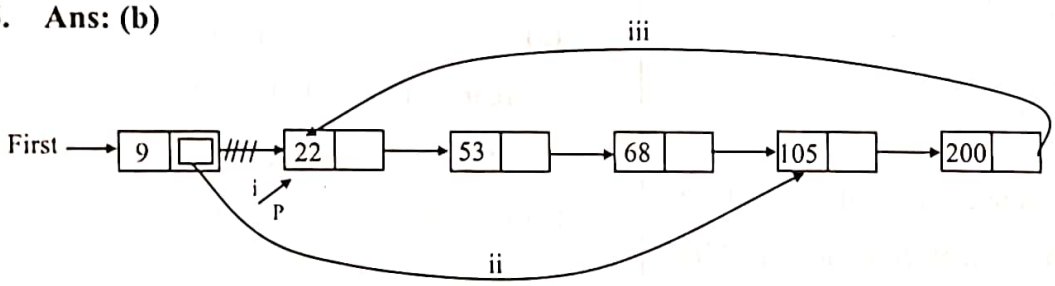
03. Ans: (b)

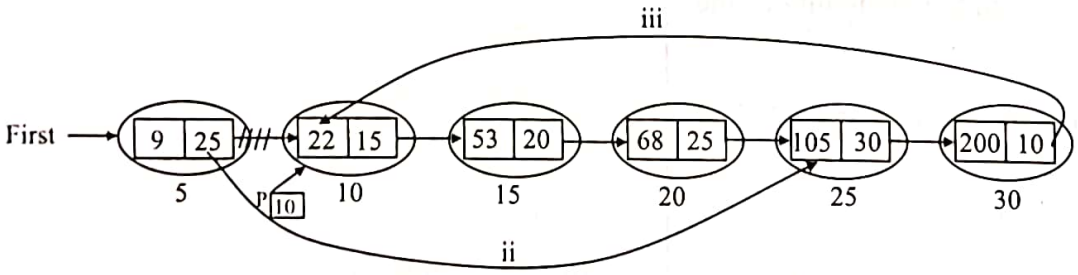
Sol: The time complexity is proportional to the length of the linked list because if there is no loop then it takes atleast half of the length of the linked list other wise it takes atleast the length of the linked list.

04. Ans: (d)

Sol: p → next → next is an address

05. Ans: (b)





(i) $\overset{\boxed{10}}{P} = \overset{5}{first} \rightarrow \overset{10}{link}$

(ii) $\overset{\square}{first} \rightarrow \overset{10}{link} = \overset{15}{P} \rightarrow \overset{20}{link} \rightarrow \overset{25}{link} \rightarrow link;$

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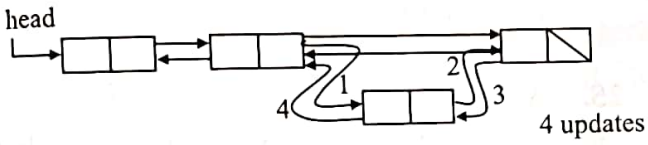
(iii) first $\xrightarrow{5}$ link $\xrightarrow{25}$ link $\xrightarrow{30}$ link $\xrightarrow{\square}$ link $\xrightarrow{10}$ = P;

(iv) printf("%d", P $\xrightarrow{10}$ link $\xrightarrow{15}$ link $\xrightarrow{20}$ link $\xrightarrow{25}$ link $\xrightarrow{30}$ link $\xrightarrow{10}$ $\boxed{22}$ data)

---

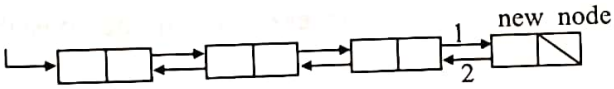
06. Ans: (b)

Sol: Inserting a node else where in the middle.



4 updates

Inserting a node right most



3 updates

07. Ans: (a)

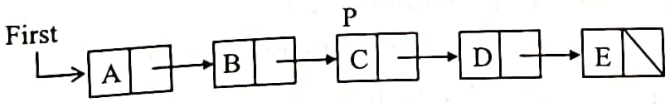
Sol: Reverses the linked list

08. Ans: (c)

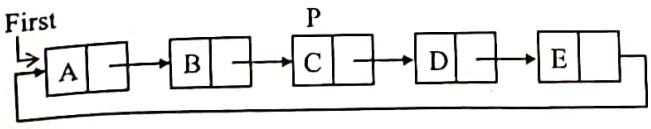
Sol: In singly linked list we can move forward but not backward.

09. Ans: (a)

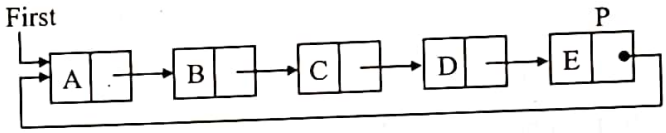
Sol: i.



ii.



iii.



iv. P → data prints E

10. Ans: (b)

Sol: if (head ! = NULL)

Insertion of element at beginning.

11. Ans: (c)

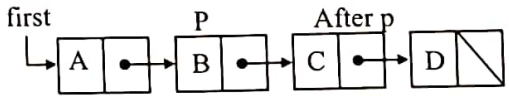
Sol: n^{th} node is accessible from $(n-1)^{th}$ node only

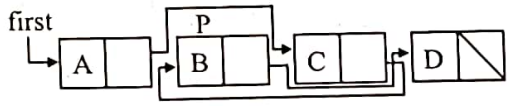
12. Ans: (a)

Sol: It merges two linked lists

13. Ans: (c)

Sol:





The output is A C B D

14. Ans: (c)

Sol: First a new node is added to the linked list next that is deleted from the linked list

∴ no change

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15. Ans: (b)

Sol: The last node address becomes the headref in the Reverse list

16. Ans: (b)

Sol: Without changing the elements of the linked list, it displays the elements in reverse order.

17. Ans: (b)

Sol: The step 2.1 → Checks whether the key value is negative and it next is not null, if it is then it deletes all the node after that node.

18. Ans: (a)

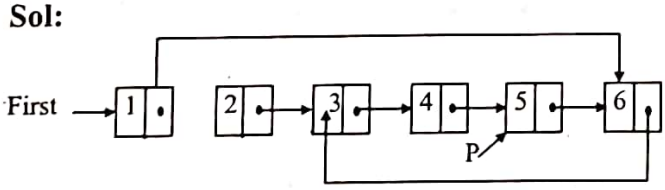
Sol: The routine uses singly linked list. By changing the links it is swapping the elements.

19. Ans: (a)

Sol: It traverses i – 1th node then it deletes ith node.

20. Ans: (d)

Sol:



21. Ans: (d)

Sol: Both changes because initially both pointers point to NULL.

22. Ans: (a)

Sol: If linked list is empty then it returns NULL.

23. Ans: (b)

Sol: It goes to infinite loop because it is circular singly linked list and L → data ! = k is true all the time.

24. Ans: (a)

Sol: The Time of delete last element depends on the length of the linked list because we need to reach to the before last node to make its next NULL.

25. Ans: (d)

Sol: → If dynamic memory is not available then linked list can be implemented using arrays

→ Random access cannot be possible in linked list

→ Graphs can be represented in networks

→ Stack – LIFO, Queue – FIFO

26. Ans: (c)

Sol: Do(NULL, First) is the function call in main function

27. Ans: (d)

Sol: To delete the last element, we need to traverse before the last node. It depends on the length of the linked list.

28. Ans: (d)

Sol: **Traversing the list**

Traversal of a doubly linked list can be in either direction. In fact, the direction of traversal can change many times, if desired. **Traversal** is often called **iteration**, but that choice of terminology is unfortunate, for **iteration** has well-defined semantics (e.g., in mathematics) which are not analogous to **traversal**.

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29. **Ans: (d)**

Sol: The above program is to find n^{th} element from the end of the linked list or in other words Given an integer 'n', return a pointer to the nth node from the end of the list.

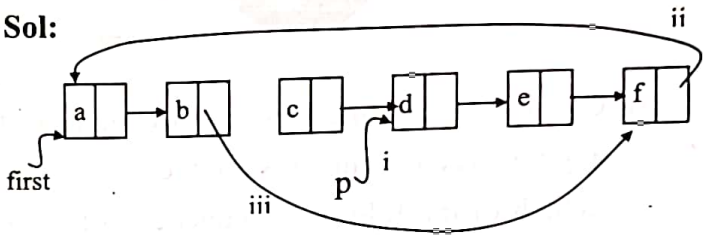
Note: Linked list is singly linked list (there is only next pointer no previous pointer).

Logic:

Keep two pointers pointer1 and pointer2, both pointing to head of the linked list initially. Increment pointer1 by one node till it reaches $(n+1)^{th}$ node. Now increment both pointers by one node till pointer1 becomes null. At this point the node which pointer2 is pointing to be the nth node from the last.

30. **Ans: (b)**

Sol:



31. **Ans: (c)**

Sol: First step is to insert element in data part. Next is to link the new node to front. Then, updating rear pointer.

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Chapter 4 Trees

01. Consider generating Binary search trees using a given set of numbers in the given order. Which of the following sequence of numbers will result in a tree that is strictly binary, i.e., every node has either two children or no children?

(a) 4 5 2 1 3 (b) 4 6 5 7 3 2

(c) 4 6 2 1 3 5 (d) 4 5 3 2 6

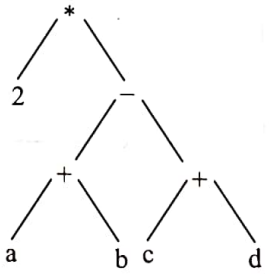
02. Which of the following arithmetic expressions directly to the parse tree given below

(a) 2 (a + b) – 2 (c + d)

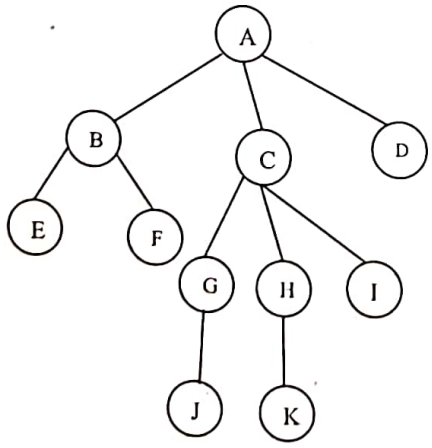
(b) 2 (a + b – c + d)

(c) 2 (a – c)

(d) 2 ((a + b) – (c + d))



03. How many nodes are required to represent the following tree using list representation



(a) 12 (b) 13 (c) 14 (d) 15

04. Start with an initially empty binary search tree and make n random insertions use a uniform random number generator to obtain the values to be inserted. Measure the resulting binary search tree and divide this height by $\log_2 n$. Do this for n=100, 500, 1000.....10000 then the ratio height / $\log_2 n$ is

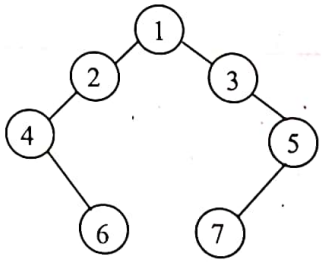
(a) a logarithmic function

(b) an exponential function

(c) a constant function

(d) a quadratic function

05. Consider the following binary tree:



If the above binary tree is represented in an array A[0...100] what is the index of the element 6?

(a) A[5] (b) A[7] (c) A[9] (d) A[8]

06. For deletion of a single item from an n – time AVL Tree, the maximum number of notations (double notations count as one rotation) is

(a) 1

(b) 2

(c) approximately $\log_2 n$

(d) approximately $1.44 \log_2 n$

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07. Nine nodes labeled 1,2,3.....9 are used to construct different binary trees. How many such binary trees can be constructed whose pre-order traversal is 1,2,3.....9.

(a) 2^9 (b) $(1/10)\ {}^{18}C_9$

(c) 9! (d) ${}^{18}C_9$

08. A binary tree T has 9 nodes. The inorder and preorder traversals of T yield the following sequence of nodes:

Inorder : E A C K F H D B G

Preorder : F A E K C D H G B

How many number of nodes are there in the left subtree of H?

(a) 3 (b) 2

(c) 1 (d) none of the above

09. The following items are inserted into binary search tree: 3, 6, 5, 2, 4, 7, 1 which node is the deepest?

(a) 1 (b) 3 (c) 4 (d) 7

10. Which of the following trees can have height that is not logarithmic?

(a) Binary Heap

(b) B – Tree of order 4

(c) AVL tree

(d) all of the above trees must have logarithmic depth

11. Let T be a B-tree of order m and height h (root is at level 1)

Let $d = \lceil m/2 \rceil$ and

n be the number of elements in T.

Which of the following statement is true?

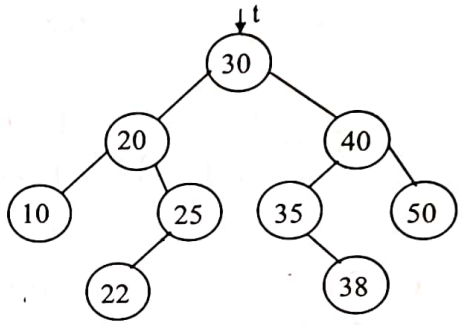
(a) $\log_m n \le h \le \log_2 (n+1)/d$

(b) $\log_m n+1 \le h \le \log_d (n+1)/2$

(c) $\log_m n \le h \le \log_2 [(n+1)/d] + 1$

(d) $\log_m n+1 \le h \le \log_d [(n+1)/2] + 1$

12. Consider binary search tree:



(A) Inorder successor of t

(B) Inorder predecessor of t

(C) Smallest in left subtree of t

(D) Largest in right subtree of t

(a) A < B < C < D (b) D > A > B > C

(c) D > B > A > C (d) A > B > C > D

13. What is the smallest and largest number of entries for 2 _3 BTree (B2_3 Tree) of height 8 (i.e., 8 levels)?

(a) 255 & 6560 (b) 127 & 2186

(c) 6561 & 255 (d) 255 & 2186

14. Consider the following keys to create AVL tree A, B, C, D, E, F

P: The number of internal nodes	1. 1
Q: The number of leaves	2. 2
R: The number of nodes having one child	3. 3
S: The number of external nodes	4. 4
	5. 6
	6. 7

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(a) P-3, Q-1, R-3, S-5
(b) P-3, Q-3, R-1, S-6
(c) P-3, Q-3, R-5, S-6
(d) P-3, Q-1, R-3, S-6

15. Supply the missing factor in the following recursive definition of the max no. of nodes in the level L of a binary tree

$$n(L)=\begin{cases}1 & L=0\\ n(L-1)+? & L>0\end{cases}$$

(a) 2^L (b) 2^{L-1}
(c) 2^L-1 (d) $2^{L-1}-1$

16. Consider the following routine:

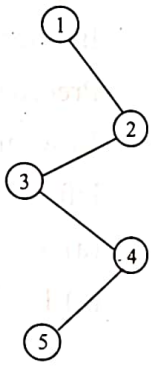
```
Bool hello(struct treenode * p)
{
    if (p == NULL)
        return 0;
    else if (p→left != 0&&p→key<p→left →key
            || p → right != 0 && p → key>
                                p → right → key)
        return false;
    else
        return hello(p→left)&&hello(p→right);
}
```

This routine is used to check whether a given tree is

(a) Max Heap (b) Binary Search Tree
(c) Min Heap (d) Binary tree

17. A BST is used to locate a number 43. Which of the following sequences are not possible?
(a) 1, 52, 14, 17, 40, 43
(b) 99, 80, 75, 78, 79, 82, 43
(c) 10, 65, 31, 48, 37, 43
(d) 81, 61, 52, 14, 41, 43

18. For the binary tree given below which of the following gives correct of vertices visited under various traversal schemes.



(a) Preorder 1,2,3,4,5
Postorder 4,5,2,3,1
(b) Preorder 1,3,2,4,5
In-order 1,3,5,4,2
(c) Post-order 5,4,3,2,1
Inorder 1,3,5,4,2
(d) None

Statement for linked Answer Questions Q19 and Q20

Consider the following elements:
42, 23, 74, 11, 65, 58, 94, 36, 99, 87

19. If you Create Max Heap, what is the right child of the root?
(a) 94 (b) 74 (c) 42 (d) 58

20. After deleting the root node, construct the max heap. Now what is the left child of 74?
(a) 94 (b) 74 (c) 42 (d) 58

21. A node with key 80 has a left child with key 100. Which of the following could be found in
(a) binary search tree (b) max heap
(c) min heap (d) two of the above

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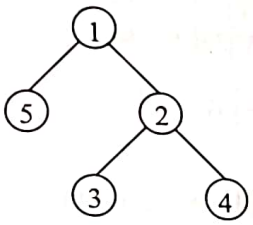
22. For the binary tree given below which of the following gives correct of vertices visited under various traversal schemes.



(a) converse Preorder 1,2,3,4,5
Postorder 4,5,2,3,1

(b) Preorder 1,5,2,3,4
Converse In-order 4,2,3,1,5

(c) Converse Post-order 5,4,3,2,1
Inorder 1,3,5,4,2

(d) None of these

23. Create arithmetic tree for the expression:
$a = 1$ or $b \times c = 2$ or ($a > 1$ and not $b < 3$)
How many levels are there for the created tree? (root @ level 0)

(a) 6 (b) 5
(c) 4 (d) 3

Common Data for Q24 and Q25

In each of the following insert the keys in-order and build them into AVL tree
21, 26, 30, 9, 4, 14, 28, 18, 15, 10, 2, 3, 7

24. Which is at the root from the above constructed AVL tree?

(a) 14 (b) 21
(c) 15 (d) 30

25. If you further delete the following keys to the above tree, then what is the root?
Keys: 2,7,10,18,26,30

(a) 3 (b) 14
(c) 21 (d) 28

26. A lexically ordered Binary tree is built for the following order of keys:
Amit, Roy, Dot, Caroll, Ann, Abbas, Adit, Shen, Acne.
Consider the following statements pertaining to the above tree:

I. Consider number of leaves in the tree as 'a'
II. Consider the number of nodes in the left subtree of root as 'b'
III. Consider the number of nodes in the right subtree of root as 'c'
IV. Consider (the root is at level one) the number of levels value as 'd'

(a) $c = d > a = b$ (b) $b < c < d < a$
(c) $c < d < a < b$ (d) $b < a < d < c$

27. A 3- ary tree in which every internal node has exactly 3 children. The number of internal nodes in such a tree with 19 nodes will be

(a) 3 (b) 4 (c) 5 (d) 6

28. The following items are inserted into an AVL tree: 8, 6, 4, 2, 3. How many rotations are performed?

(a) 2 rotations
(b) 1 single rotation only
(c) 1 double rotation only
(d) 1 single rotation and 1 double rotation

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29. AVL tree is created with the keys:

2, 1, 4, 5, 9, 3, 6, 7

Consider the following statements:

1. Consider inorder predecessor of root node as 'a'.
2. Consider the root node value as 'b'
3. Consider the inorder successor of root node as 'c'.
4. Consider the right child of root node as 'd'.

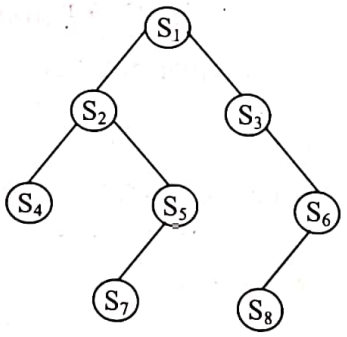
Choose the right option:

(a) a < b < c < d
(b) a < c < d < b
(c) d < a < b < c
(d) b < c < a < d

30. Consider the following Tree T

If 'T' is a binary search tree, which of the following is the fourth smallest element?

(a) S_2
(b) S_3
(c) S_5
(d) S_7



31. Construct minimal AVL tree of height 0, 1, 2, 3, 4, 5. What is the number of nodes in a minimal AVL Tree of height 6?

(a) 30
(b) 43
(c) 33
(d) None

32. What is the Post-order for a given pre-order 3 1 2 4 5 of binary search tree?

(a) 2 5 4 1 3
(b) 3 1 4 5 2
(c) 5 4 2 1 3
(d) 2 1 5 4 3

33. In the following array representation of binary heap, how many nodes are in the right subtree of the root of the heap?

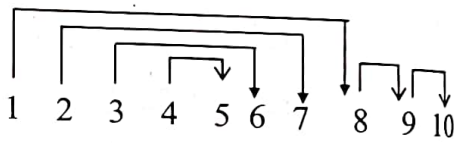
i:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A[i]:	11	23	19	31	27	26	31	46	45	38	31	35	37	63	82	71	95

(a) 5
(b) 6
(c) 7
(d) 8

34. Consider the following Notation

RPTR

Pre-order



What is Inorder

(a) 1 2 3 4 5 6 7 8 9 10
(b) 4 5 3 6 7 2 1 9 8 10
(c) 5 4 6 3 7 2 10 9 8 1
(d) 4 5 3 6 2 7 1 8 9 10

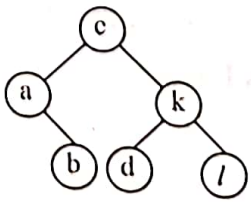
35. Generate *Binary tree* for the below given orders and what is post-order of the generated binary tree?

PRE: 5 2 1 4 3 6 8 7

IN: 1 2 3 4 5 6 7 8

(a) 1 3 4 2 7 8 6 5
(b) 1 4 2 3 8 7 6 5
(c) 3 4 2 1 6 8 5 7
(d) 1 6 3 4 6 7 8 5

36. What is the cost of the binary search tree given below? Assume that the probabilities of internal and external nodes is one



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(a) 1.5 (b) 1.0
(c) 0.95 (d) none

37. Consider the following program to count the number of leaf nodes in a binary search tree:

```
void leaf_count(node *t, int *count)
{
  if ((t → left) && (t → right))
  {
    leaf_count(.....(1).....,.....(2).....);
    leaf_count(.....(3).....,.....(4).....);
  }
  else
    ++(*count);
}
```

Statements (1),(2), (3) and (4) can be

(a) t → left, count, t → right, count
(b) t → right, ++count, t → left, ++count
(c) t → left, ++count, t → right, ++count
(d) t → right, count, t → left, count

38. **Assertion (a)**: While evaluating a postfix expression, operators should be pushed into stack.

Reason (r): Finally, the result is available at the bottom most of stack.

(a) Both [a] and [r] are true and [r] is the reason for [a].
(b) Both [a] and [r] are true but [r] is not the correct reason for [a].
(c) Both [a] and [r] are false.
(d) [a] is true but [r] is false.

39. The following routine computes the number of nodes in the tree.

Find the missing parameter.

```
/* Compute the number of nodes in a tree.*/
int size(struct node* node)
{
        if (node==NULL)
        {
                return(0);
        }
        else
        {
                return(?);
        }
}
```

(a) size(node → left) + size(node → right)
(b) size(node → left)
(c) size(node → left) + 1 + size(node→right)
(d) size(node → right)

Statement for Linked answer Q40 and Q41 is given below.

A full binary tree is the one which has max number of nodes for a given level. At level i, you have 2^{i-1} nodes similarly full m-ary tree with n nodes.

40. The number of leaves say i

(a) i = ((m+1)n+1)/m (b) i=((m−1)n−1)/m
(c) i=((m+1)n−1)/m (d) i=((m−1)n+1)/m

41. For a given full 3-ary tree with 27 leaves, find the internal nodes.

(a) 4 (b) 13 (c) 27 (d) 40

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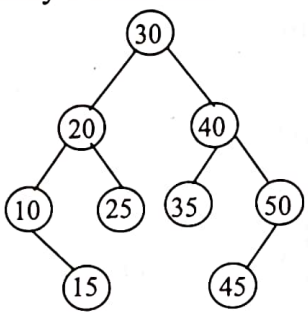
42. Consider indexed binary search tree:



(1) Index of the root
(2) Index of the node 20
(3) Index of the node 35
(4) Index of the node 40

Which is true?

(a) $1 < 2 < 3 < 4$ (b) $4 > 1 > 2 > 3$
(c) $3 < 4 < 2 < 1$ (d) $1 > 2 > 4 > 3$

43. Match the following:

Data: The keys are inserted into an AVL tree: 1, 2, 3, 8, 6

List – I	List – II
P: The root node	A : 1
Q: Number of nodes in left sub tree of root	B : 2
R: Number of nodes in right sub-tree of root	C : 3
	D : 4

(a) P-A,Q-B,R-C (b) P-B,Q-D,R-C
(c) P-B,Q-A,R-C (d) P-C,Q-B,R-A

44. Create a Binary search tree for the following keys 7, 6, 5, 4, 3, 2, 1 Perform <u>two</u> 'zig – zig' notations at node 1. How many nodes are present in the right subtree of node 1 of the resultant tree.

(a) 3 (b) 4 (c) 5 (d) 6

45. Suppose an A.V.L Tree is constructed with the following set of identifiers:

RI, PA, DE, GA, OH, MA, IL, MI, IN, NY, VT, TX, AND, WY in order.

The root of the above Tree is

(a) MA (b) TX (c) AND (d) None

46. If a tree has n_1 nodes of degree 1, n_2 nodes of degree 2, n_m nodes of degree m, then number of terminal nodes it has

(a) $n_1 + 2n_2 + 3n_3 + \ldots\ldots + mn_m$
(b) $1 + n_1 + 2n_2 + 3n_3 + \ldots\ldots + mn_m$
(c) $n_1 + n_2 + n_3 + \ldots\ldots + n_m$
(d) None

47. Consider the following statements:

I. AVL tree is created with the items: 1,2,3,8,6. Consider the root node value as 'a'.
II. Binary search tree is created with the items: 3, 6, 5, 2, 4, 7, 1. Consider the deepest node value as 'b'.
III. AVL tree is created with the items: 7, 3, 11, 9, 13. Consider the root node value as 'c'.
IV. Binary search tree is created with the items: 1, 3, 5, 7, 6, 4, 2. Consider the root node as 'd'

(a) $a > b > c > d$ (b) $a > c > d > b$
(c) $d < a < b < c$ (d) $d < c < a < b$

Statement for linked answer Questions 48 & 49

Insert the keys in the order given below to built them into an AVL tree:

A, Z, B, Y, C, X, D, W, E, V, F.

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48. What is the root?
(a) C (b) D (c) E (d) V

49. From the above generated AVL tree, if A, Z, B, Y, C keys are deleted, then what is the root?
(a) C (b) D (c) E (d) V

50. Create AVL tree for the nodes 70, 60, 80, 50, 65 and 68. How many leaves are there in the resultant tree?
(a) 2 (b) 3 (c) 4 (d) 5

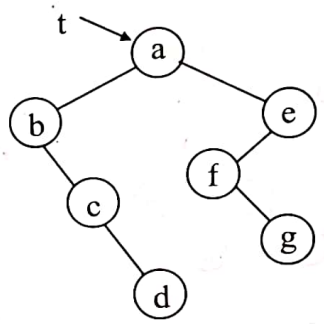
51. The number of binary trees with 3 nodes, which when Traversed in post order gives the sequence A, B, C is _____
(a) 3 (b) 9 (c) 7 (d) 5

52. A binary search tree is generated by inserting in order the following integers:
50, 15, 62, 5, 20, 58, 91, 3, 8, 37, 60, 24
The number of nodes in the right subtree of the root respectively is
(a) 7 (b) 8 (c) 4 (d) 3

53. Consider the following binary tree and program

```
void Do (struct BT node *t)
{   if (t)
    {   printf ("%d", t → data);
        Do (t → llink);
        printf("%d", t → data);
        Do (t → rlink);
        printf("%d", t → data);
    } }
```

Do (t) = _____?



(a) aaa bbb ccc ddd eee fff ggg
(b) abb ccd ddc bae ffg ggf eea
(c) abc def gab cde fga bcd efg
(d) abb ccd ddc bae eff ggg fea

54. What is the post order of the binary search tree whose preorder traversal is given as e, d, a, b, c, i, g, f, h
(a) c, b, a, d, f, h, g, i, e
(b) b, c, d, a, h, f, g, i, e
(c) i, e, b, c, d, a, h, f, g
(d) c, b, a, f, h, d, g, i, e

55. Identify **valid** search sequence of 35.
(a) 4, 90, 72, 64, 58, 37, 38, 35
(b) 100, 64, 79, 82, 57, 4, 8, 35
(c) 100, 81, 79, 71, 46, 13, 17, 35
(d) 66, 2, 4, 11, 79, 82, 41, 35

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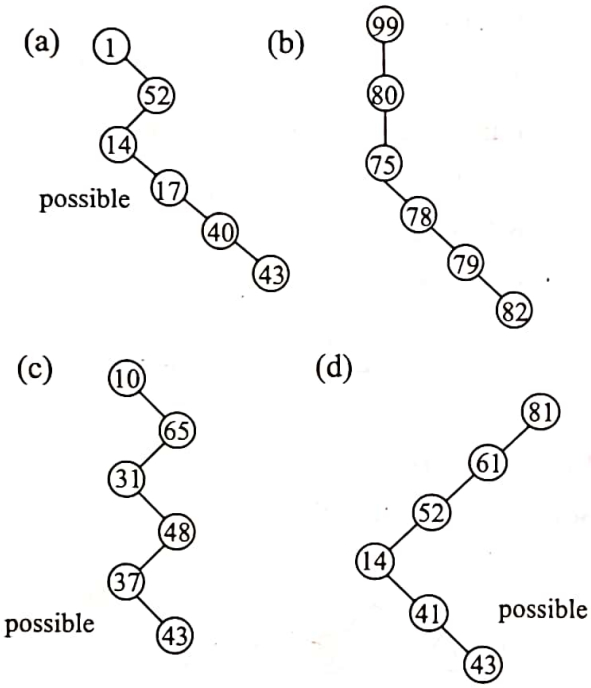
16. Ans: (b)

Sol: It checks whether the tree is Binary Search tree or not

17. Ans: (b)

Sol:



18. Ans: (c)

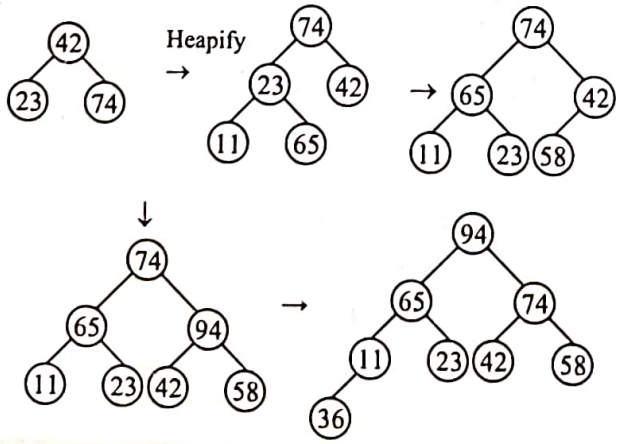
Sol: Inorder Traversal: 1, 3, 5, 4, 2

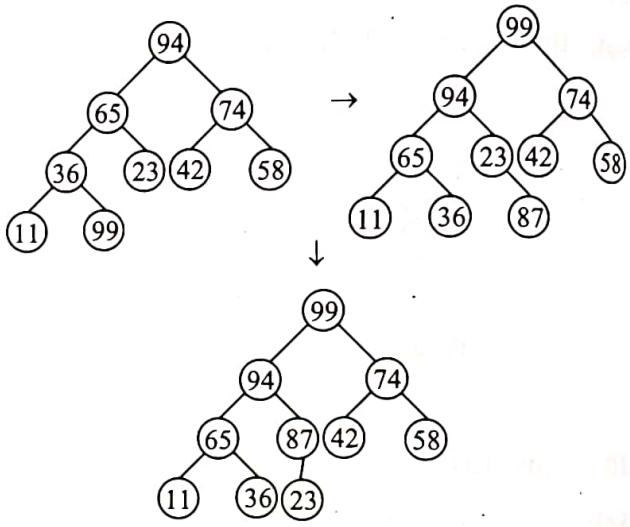
Preorder: 1, 2, 3, 4, 5

Postorder: 5, 4, 3, 2, 1

19. Ans: (b)

Sol:

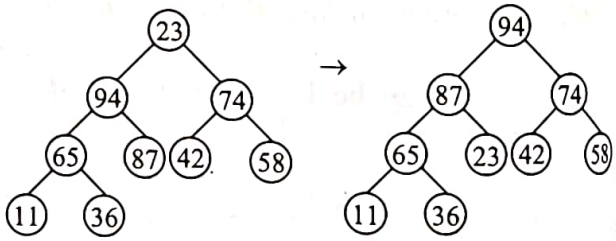




right child of root = 74

20. Ans: (c)

Sol: After deleting the root



left child of 74 is 42

21. Ans: (c)

Sol: This is possible only in Min Heap

22. Ans: (b)

Sol: Inorder Traversal: 5 1 3 2 4

Preorder Traversal: 1 5 2 3 4

Postorder Traversal: 5 3 4 2 1

Converse Inorder Traversal: 4 2 3 1 5

Converse Preorder: 1 2 4 3 5

Converse Postorder: 4 3 2 5 1

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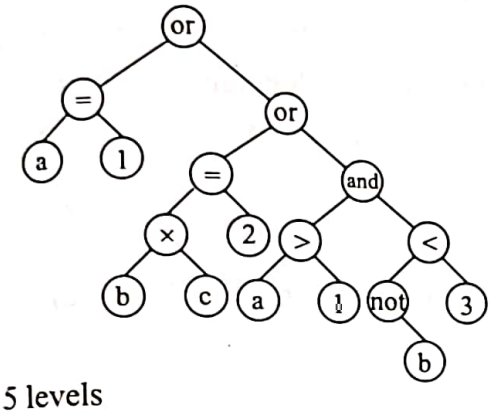
23. Ans: (b)

Sol:

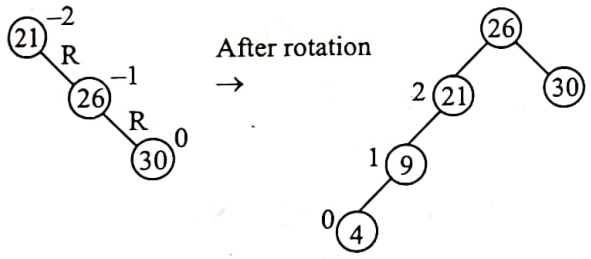


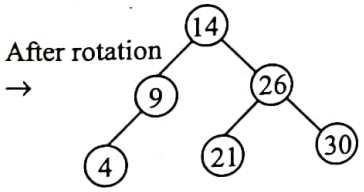
5 levels

24. Ans: (a)

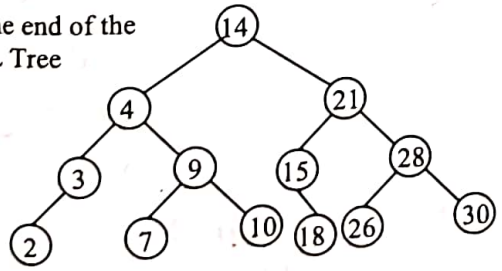
Sol: Insert

21, 26, 30, 9, 4, 14, 28, 18, 15, 10, 2, 3, 7





At the end of the AVL Tree

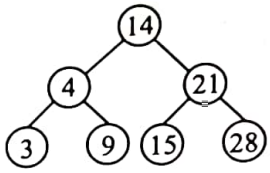


root = 14

25. Ans: (b)

Sol: Delete 2, 7, 10, 18, 26, 30

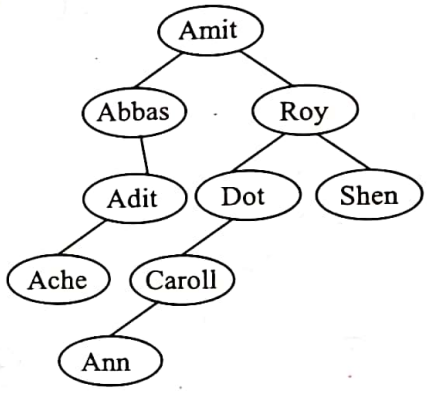
The AVL Tree



root = 14

26. Ans: (a)

Sol:



a = leaf nodes = 3

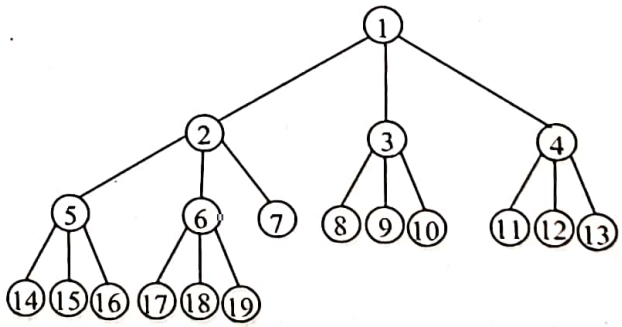
b = number of nodes in left subtree = 3

c = number of nodes in right subtree = 5

d = levels = 5

27. Ans: (d)

Sol:



6 nodes are internal nodes

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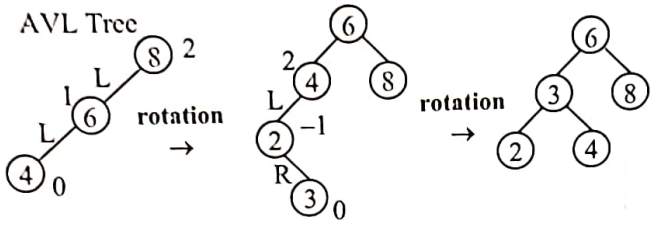
28. Ans: (a)

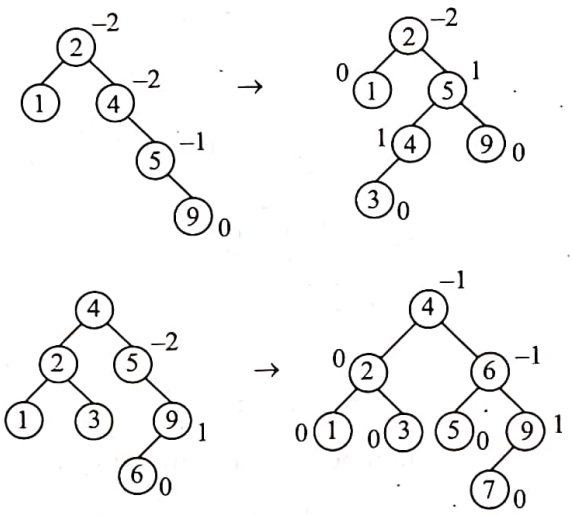
Sol:



2 rotations

29. Ans: (a)

Sol: AVL tree creation with 2, 1, 4, 5, 9, 3, 6, 7



Inorder Traversal: 1 2 3 4 5 6 7 9

root

a = Inorder predecessor of root = 3

b = root = 4

c = Inorder successor of root = 5

d = right child of root = 6

a < b < c < d

30. Ans: (c)

Sol: Inorder traversal produces sorted output

$S_4, S_2, S_7, S_5, S_1, S_3, S_8, S_6$

S_5 is the 4th smallest element

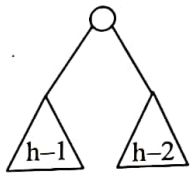
31. Ans: (c)

Sol: Let N (h) be the no. of nodes in a minimal AVL Tree with height h.

N (0) = 1

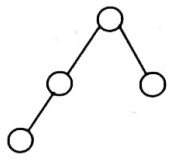
N (1) = 2

N (h) = 1 + N (h – 1) + N (h – 2)



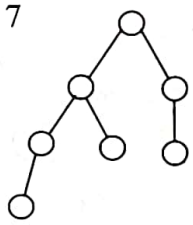
N (2) = 1 + N (1) + N (0)

= 1 + 2 + 1 = 4



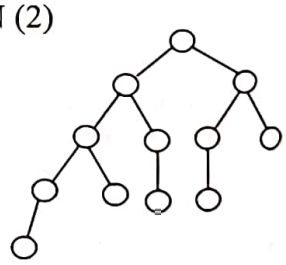
N (3) = 1 + N (2) + N (1)

= 1 + 4 + 2 = 7



N (4) = 1 + N (3) + N (2)

= 1 + 7 + 4 = 12



N (5) = 1 + N (4) + N (3)

= 1 + 12 + 7 = 20

N (6) = 1 + N (5) + N (4)

= 1 + 20 + 12 = 33

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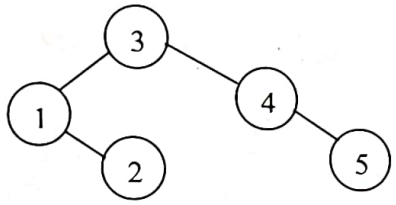
32. Ans: (d)

Sol: pre order 3 1 2 4 5

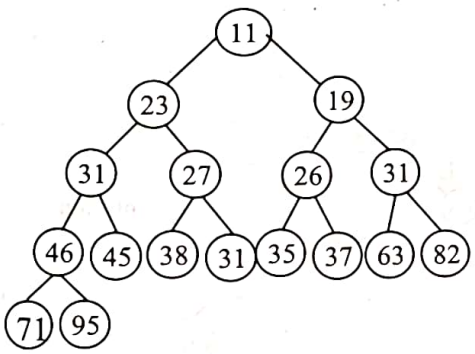
Inorder 1 2 3 4 5 (Since BST, it is implied as ascending order)



So Post order is 2 1 5 4 3

33. Ans: (c)

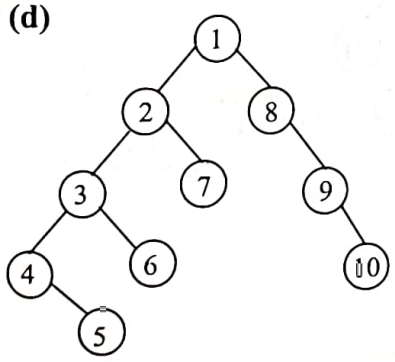
Sol:



∴ Right subtree of the root of the heap contain '7' nodes

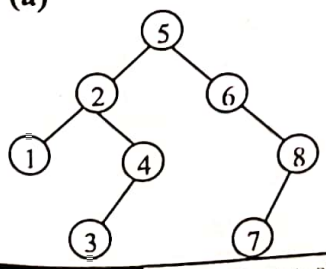
34. Ans: (d)

Sol:



35. Ans: (a)

Sol:



36. Ans: (d)

Sol: Cost (binary search tree) = ∑ level(Internal node) * prob(node) + ∑(level(External node)–1) * prob(External node)

= (1*1+2 *1+3 * 1 + 2 * 1 + 3 * 1 + 3 * 1)+ (2*1+3 *1+3* 1+3 * 1+3 * 1+3 * 1+3 * 1)

= (1+2+3+2+3+3) + (2+3+3+3+ 3 + 3 + 3)

= 14 + 20 = 34

37. Ans: (a)

Sol: If the node is a leaf node then only count is incremented otherwise there is no change in the count.

38. Ans: (c)

Sol: Operands are pushed into stack.

At the end the result is poped.

39. Ans: (c)

Sol: 1 + size (node → left) + size (node → right)

It counts root + its number of nodes in right and left subtrees

40. Ans: (d)

Sol: At level i, there are 2^{i-1} nodes in binary tree.

m – ary tree, at level i there are m^{i-1} nodes.

The total number of nodes

$n = 1 + m + m^2 + \ldots\ldots + m^i$

$$\Rightarrow \frac{m^{i+1}-1}{m-1} = n$$

$$m^{i+1} - 1 = n(m-1)$$

$$m^{i+1} = n(m-1)+1$$

$$m^i = \frac{(n(m-1)+1)}{m}$$

→ This gives the number of leaf nodes.

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41. Ans: (b)

Sol: 3–ary, 27 leaves,

$$27 = \frac{(n(m-1)+1)}{m}$$

$m = 3 \Rightarrow n(2) + 1 = 27 * 3$

$2n + 1 = 81$

$2n = 80 \Rightarrow n = 40$

Total number of nodes = 40

Leaves = 27

Internal nodes = 40 – 27 = 13

42. Ans: (c) & (d)

Sol: (1) Index of the root is 4

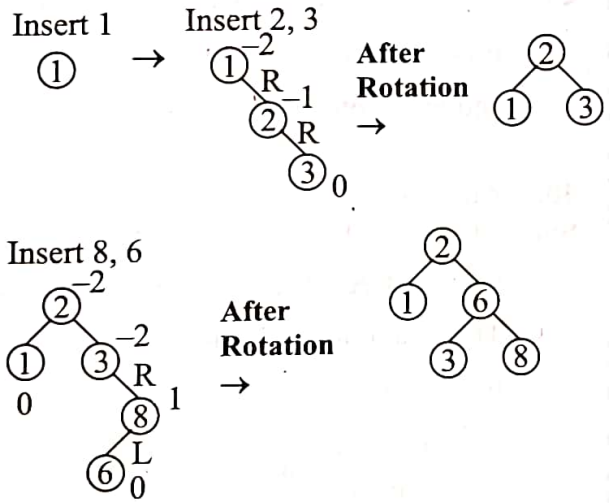
(2) Index of the node 20 is 2

(3) Index of the node 35 is 0

(4) Index of the node 40 is 1

43. Ans: (c)

Sol:



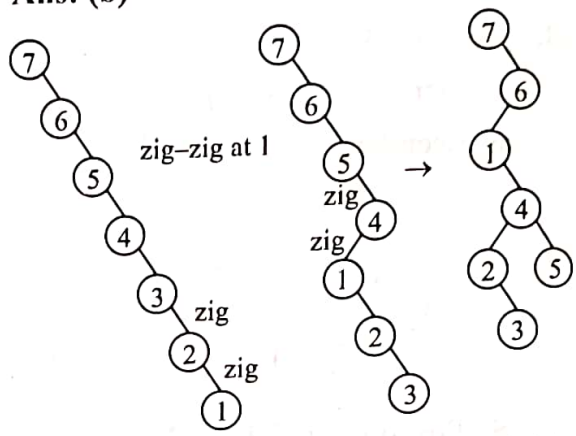
P: root node is 2

Q: Number of nodes in left subtree of root is 1

R: Number of nodes in right subtree of root is 3

44. Ans: (b)

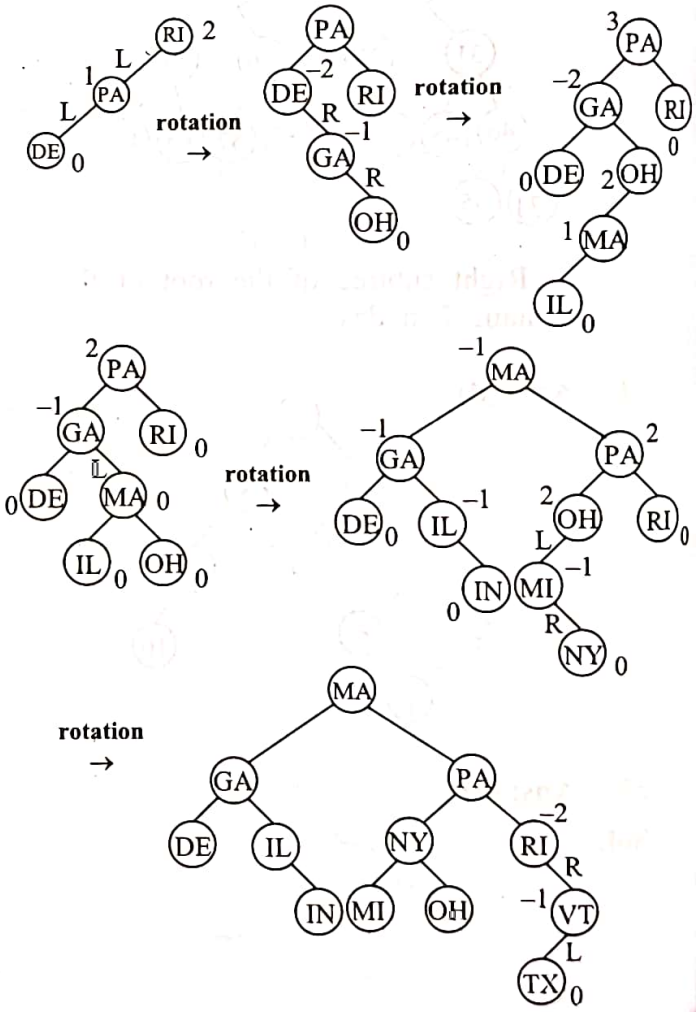
Sol:



Number of nodes in right subtree of node 1 is 4

45. Ans: (a)

Sol:



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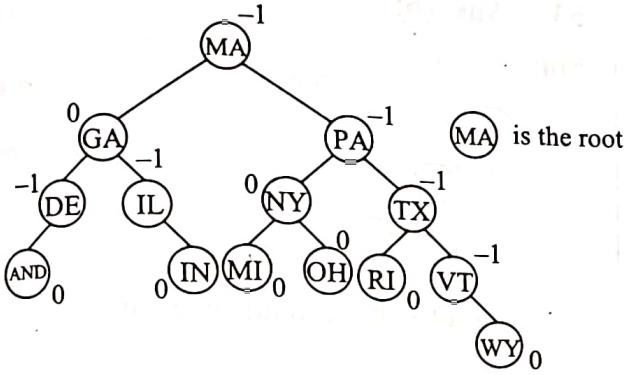


46. Ans: (d)

Sol: number of edges = sum of the degrees of all the nodes

Total number of nodes –1

$= 1*n_1 + 2*n_2 + \ldots + m*n_m$

Total number of nodes $= n_1 + n_2 + \ldots + n_m$

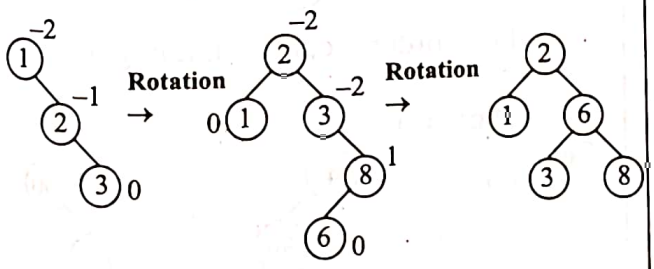
$n_0 + n_1 + n_2 + \ldots + n_{m-1} = 1*n_1 + 2*n_2 + \ldots + m*n_m$

$n_0 \rightarrow$ terminal node

$n_0 = 1 + [n_2 + 2n_3 + \ldots + (m-1)*n_m]$

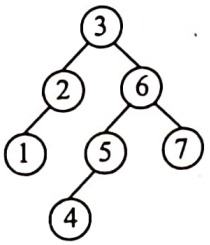
47. Ans: (c)

Sol: I. AVL tree creation with 1, 2 3, 8, 6



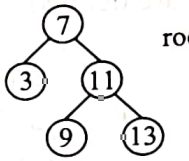
root node value a = 2

II. BST with 3, 6, 5, 2, 4, 7, 1



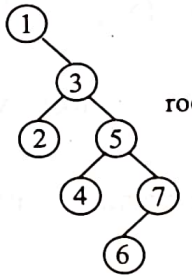
deepest node value b = 4

III. AVL Tree creation with 7, 3, 11, 9, 13



root node value c = 7

IV. BST

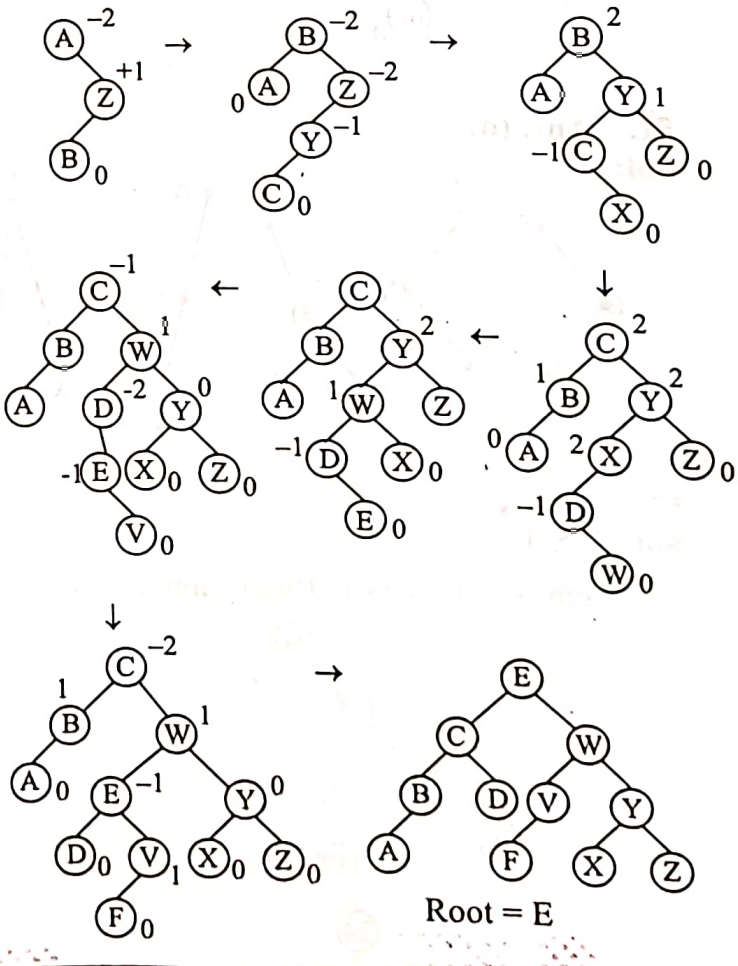


root node value d = 1

$d < a < b < c$

48. Ans: (c)

Sol: AVL Tree creation with A, Z, B, Y, C, X, D, W, E, V, F



Root = E

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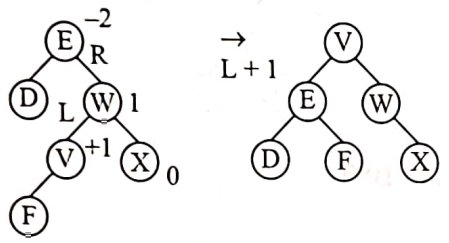
49. Ans: (d)

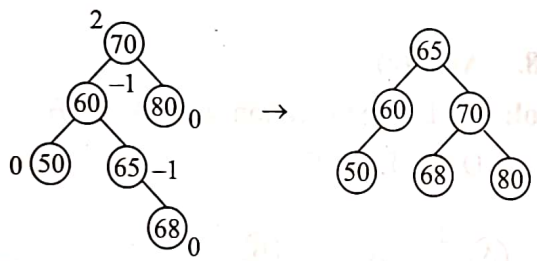
Sol: If A, Z, B, Y, C are deleted



root = V

50. Ans: (b)

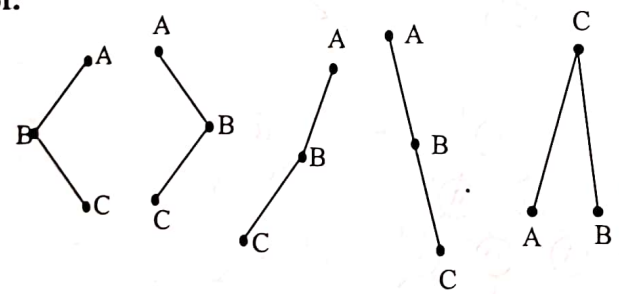
Sol: AVL tree creation with 70, 60, 80, 50, 65, 68



3 leaves

51. Ans: (d)

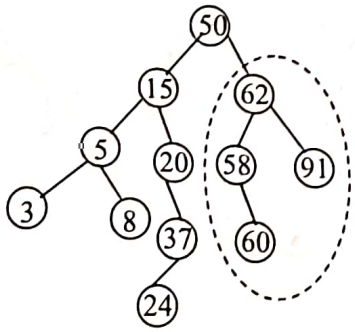
Sol:



52. Ans: (c)

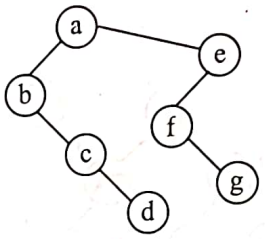
Sol: B.S.T

Number of nodes in Right subtree = 4



53. Ans: (b)

Sol:



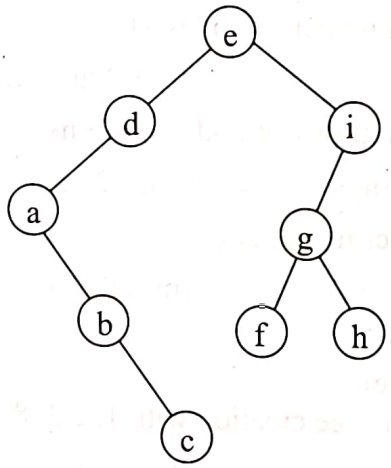
1 print
2 Left traverse
3 print
4 Right traverse
5 print

output = abb ccd ddc bae ffg ggf eea.

54. Ans: (a)

Sol: Pre–order = e, d, a, b, c, i, g, f, h

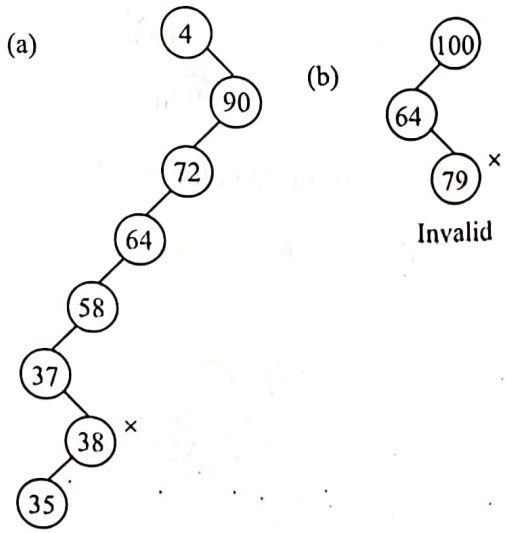
In–order = a, b, c, d, e, f, g, h, i



Post–order = c, b, a, d, f, h, g, i, e

55. Ans: (c)

Sol:



Invalid

Invalid

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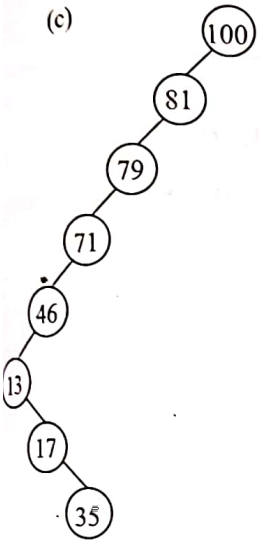
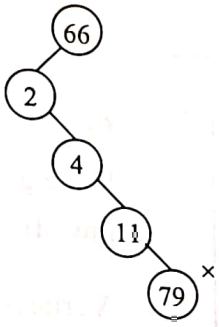
(c)



valid

(d)



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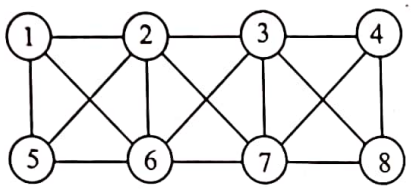
Chapter 5 Graphs

01. Identify valid BFS search sequences



(a) 1, 5, 2, 3, 4, 7, 6, 8
(b) 1, 2, 5, 6, 7, 4, 3, 8
(c) 1, 2, 5, 6, 7, 3, 4, 8
(d) 1, 5, 2, 7, 6, 3, 4, 8

02. Let T be a DFS tree in an undirected graph G. Let vertices u and v are leaves of this tree T. The degree of both u and v in G is atleast 2. Which one of the following statement is **TRUE** ?
(a) There must exist a vertex 'w' adjacent to both u and v in G.
(b) There must exist a vertex 'w' whose removal disconnects u and v in G.
(c) There must be exist a cycle in 'G' containing 'u' and 'v'.
(d) There must exist a cycle in G containing u and all its neighbours in G.

03. Which algorithm is used to compute minimum spanning tree
(a) Breadth – First Search
(b) Depth – First Search
(c) Kruskal's
(d) Both (a) & (b)

Common Data for Q04 and Q05

If the graph representation is mixed (array + linked)

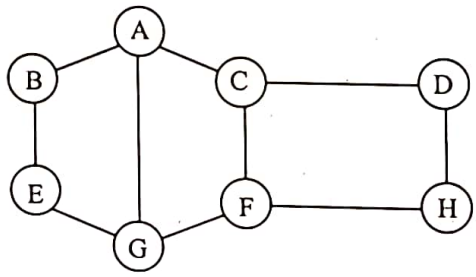
Vertices	Adj		
1	2	3	4
2	1	5	
3	1	5	
4	1	6	7
5	2	3	8
6	4	8	
7	4	8	
8	5	6	7

If Depth First Traversal is used

04. Which vertices are ***not*** pushed into stack?
(a) 3 (b) 4 (c) 7 (d) a & c

05. How many times vertex 8 is pushed into stack?
(a) 0 (b) 1 (c) 2 (d) 3

06. Give the breadth first traversal of the given adjacency list graph below starting from vertex A.



(a) A, B, E, G, C, F, D, H
(b) A, B, C, G, E, D, F, H
(c) A, B, C, F, G, D, H, E
(d) A, B, C, G, H, D, F, E

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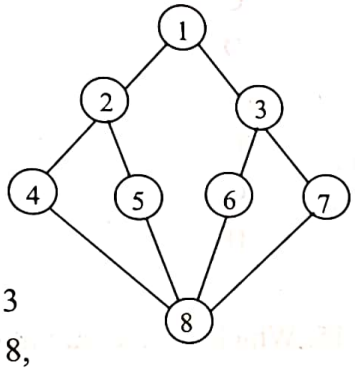
07. A regular graph is denoted by k_n where n is number of vertices in which every vertex is connected to every other vertex. Then the number of distinct spanning trees possible for k_n

(a) n^{n-2} (b) n^2
(c) n^3 (d) n^{n-1}

08. Consider the following graph and breadth first traversal is used starting at vertex 5, then



(a) 5, 2, 8, 1, 4, 6, 7, 3
(b) 5, 2, 3, 4, 2, 6, 7, 8,
(c) 5, 8, 2, 6, 7, 4, 3, 1
(d) 5, 2, 8, 4, 1, 3, 7, 6

09. Pickup the correct statement with respect to DFS algorithm.

S1: Depth first traversal continues to visit the first unvisited successor of each node as long as possible

S2: Depth first traversal first visits all the immediate successors of a node before moving to their successors

S3: Certain nodes are not pushed into the stack

S4: Certain nodes are pushed into stack for more than once

(a) S2, S3 (b) S1, S3
(c) S1, S4 (d) S1, S3, S4

10. Consider the following representation for a Graph:

Vertex vector: A B C D E F G H

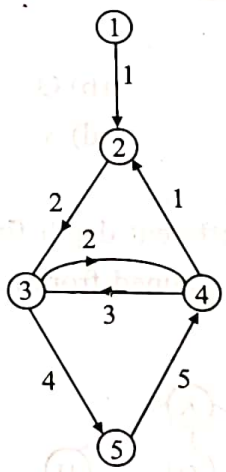
Adjacency Matrix

	A	B	C	D	E	F	G	H
A	0	1	1	0	0	0	1	0
B	1	0	0	0	1	0	0	0
C	1	0	0	1	0	1	0	0
D	0	0	1	0	0	0	0	1
E	0	1	0	0	0	0	1	0
F	0	0	1	0	0	0	1	1
G	1	0	0	0	1	1	0	0
H	0	0	0	1	0	1	0	0

If the Depth First Traversal is used with the starting vertex G, then for how many times the vertex 'A' is pushed into the stack

(a) nil (b) one
(c) two (d) three

11. The eccentricity of node labeled 5 in the Graph in fig is _____.



(a) 6 (b) 7 (c) 8 (d) 5

12. A graph with "n" vertices and n-1 edges that is not a tree, is

(a) Connected (b) Disconnected
(c) Euler (d) A circuit

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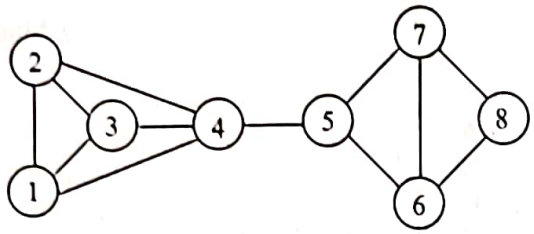
13. Consider the Graph



If the starting vertex is VI, pickup the **incorrect** statement to visit the vertices in the following order:

1, 2, 3, 4, 5, 6, 7, 8

P: It is Depth First traversal

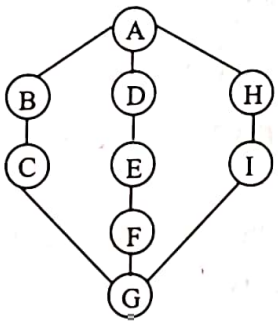
Q: It is Breadth First traversal

R: While traversing using DFS to get the above order, certain vertices are pushed into stack for more than once

S: While traversing using BFS to get the above order, no vertex is enqueued for more than once.

(a) P (b) Q
(c) R (d) S

14. The number of different depth first spanning trees that can be obtained from the following graph are



(a) 3 (b) 4 (c) 6 (d) 1

Statement for Linked answer Q15 and Q16 is given below.

If the graph representation is mixed (array +linked) as shown below and depth first traversal is used, then

Vertices		Adjacency
A	:	B C G
B	:	A E
C	:	A D F
D	:	C H
E	:	B G
F	:	C G H
G	:	A E F
H	:	D F

15. Which vertices are not pushed into the stack

(a) A (b) D
(c) F (d) H

16. How many vertices are pushed into the stack for more than once starting vertex is A

(a) 0 (b) 1
(c) 2 (d) 3

For Question No. 17 & 18 there are two statements Assertion (a) and Reason (r). Choose:

(a) Both (a) and (r) are true and (r) is the correct reason for (a).

(b) Both (a) and (r) are true and (r) is not the correct reason for (a).

(c) Both (a) and (r) are false.

(d) (a) is true but (r) is false.

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17. **Assertion (a):** For a given graph with all edges having different weights, there is a unique minimum spanning tree.
Reason (r): For a given graph, in general, there can be more than one spanning tree.

18. **Assertion (a):** A queue is used for breadth-first traversal.
Reason (r): Breadth first traversal first visits all the immediate successors of a node before moving to their successors

19. Pickup the ***correct*** statement with respect to BFS algorithm.
S_1: Breadth first traversal continues to visit the first unvisited successor of each node as long as possible
S_2: Breadth first traversal first visits all the immediate successors of a node before moving to their successors
S_3: All nodes are not enqueued.
S_4: While traversing using BFS, no vertex is enqueued for more than once

(a) S2, S3 (b) S1, S3
(c) S1, S4 (d) S2, S4

Common Data for Q20 and Q21

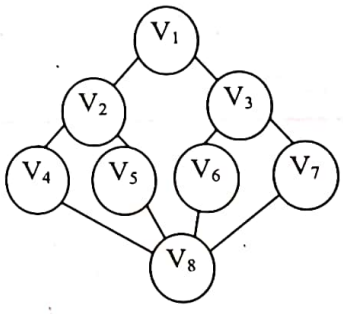
1	:	2	3	6
2	:	1	4	
3	:	1	4	5
4	:	2	3	8
5	:	3	6	8
6	:	1	5	7
7	:	6	8	
8	:	4	5	7

Starting vertex v1
Traversal: DFS

20. Which vertex is not pushed in stack?
(a) v4 (b) v5
(c) v7 (d) v8

21. What is the possible recursion depth (including initial call) _____

22. Identify ***invalid*** BFS search sequences



(a) 2 1 4 5 3 8 7 6 (b) 5 8 2 6 7 4 1 3
(c) 6 3 8 1 7 5 4 2 (d) 3 1 6 2 7 5 4 8

Common Data for Q23 & Q24:

The graph is represented as follows:

Vertex		Adjacency
V1	=	3, 2
V2	=	5, 4, 1
V3	=	7, 6, 1
V4	=	8, 2
V5	=	8, 2
V6	=	8, 3
V7	=	8, 3
V8	=	7, 6, 5, 4

Traversal = DFS
Starting Vertex = V6

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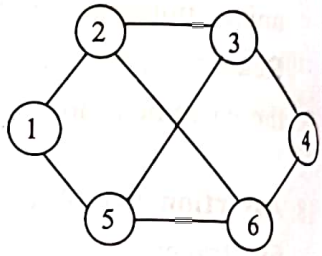
23. What vertices are not pushed in?

(a) 5, 6 (b) 5, 7
(c) 4, 5, 7 (d) 8

24. What vertices are pushed in for more than once?

(a) 3, 6 (b) 3, 8
(c) 8 (d) 5

25. Consider BFS algorithm. The starting vertex is v5, how many are the valid BFS sequences?



i) 5 1 2 4 6 3
ii) 5 3 1 6 4 2
iii) 5 6 1 4 3 2
iv) 5 6 1 3 4 2

(a) i, ii (b) ii, iii
(c) i, iv (d) ii, iv

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Solutions

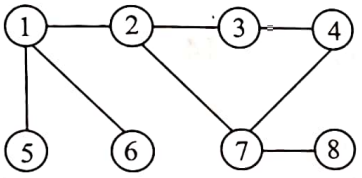
01. Ans: (c)

Sol:

(a) 1 5 2 Invalid, 6 is missing

(b) 1 2 5 6 7 4 Invalid, 3 is missing

(c)

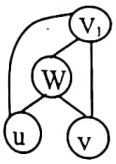


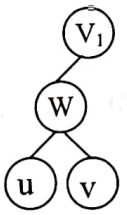
valid

(d) 1 5 2 7 Invalid, 6 is missing

02. Ans:(a)

Sol: G T: Depth first search of G

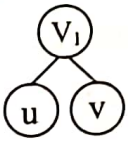




According to the question u and v are leaves of the tree T and the degree of both u and v in G are 2.

Option (a): There must exist a vertex 'w' adjacent to both 'u' and 'v' in G, so it is true.

Option (b): There must exist a vertex 'w' whose removal disconnects u and v in G is false because when we remove 'w' from G graph is connected as

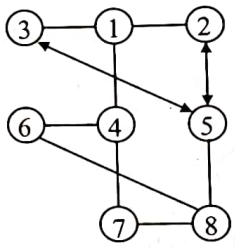


03. Ans: (c)

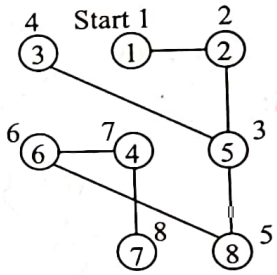
Sol: Kruskal's algorithm produces MSP.

04. Ans: (d)

Sol: From the given representation the graph, G is



DFT starts at 1

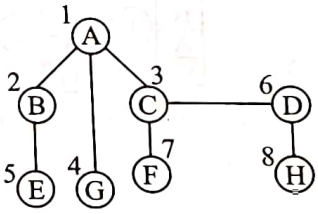


05. Ans: (b)

Sol: 8 is pushed only once.

06. Ans: (b)

Sol:



numbering outside the node is the order

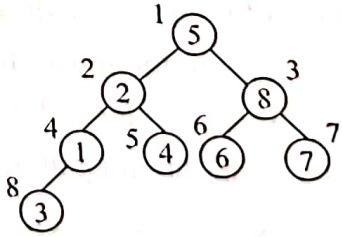
07. Ans: (a)

Sol: Possible distinct spanning trees for a regular graph is n^{n-2}.

08. Ans: (a)

Sol: Starting vertex is ⑤

Breadth First Traversal



$\Rightarrow$ 5, 2, 8, 1, 4, 6, 7, 3

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(b) is false because after 2 it must be 8

(c) is false because after 4 it must be 1

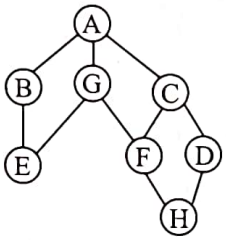
(d) is false because after 1 it must either 6 or 7

09. Ans: (d)

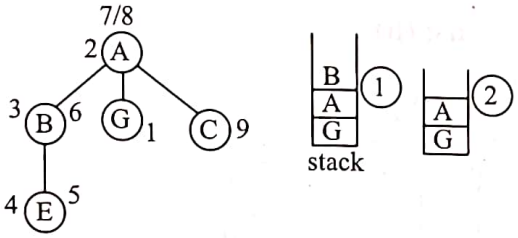
Sol: Functionalities of DFS.

10. Ans: (c)

Sol:



Depth First Traversal, starting vertex G



A is pushed two times into the stack. One time after G another time after E.

11. Ans: (b)

Sol: Eccentricity of a given node, is the maximum of minimum path from other nodes to the given node.

Cost of minimum path from 1 to 5 is 7

Cost of minimum path from 2 to 5 is 6

Cost of minimum path from 3 to 5 is 4

Cost of minimum path from 4 to 5 is 7

∴ Since the maximum is 7 and Eccentricity of node 5 is 7.

12. Ans: (b)

Sol: A graph with n vertices and n −1edges that is not a tree is disconnected. The rank of the incidence matrix of such a graph will be less than n −1.

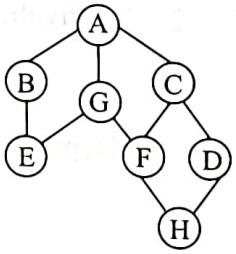
Therefore the (n−1) by (n−1) reduced incidence matrix of such a graph will not be non singular. In other words, the reduced incidence matrix of a graph is non singular if and only if the graph is a tree.

13. Ans: (c)

14. Ans: (c)

15. Ans: (d)

Sol: From the graph representation, the graph is



DFT: A, B, E, G, F, C, D, H → H is not pushed into stack.

16. Ans: (a)

Sol:

A B E G F C D H

A ~~B~~ ~~E~~ ~~G~~ B C D

Stack

17. Ans: (b)

18. Ans: (a)

Sol: (a) and (r) are correct. (r) gives the BFT process

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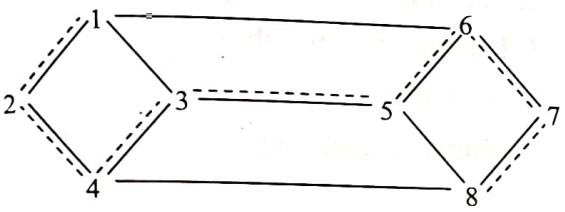
19. Ans: (d)

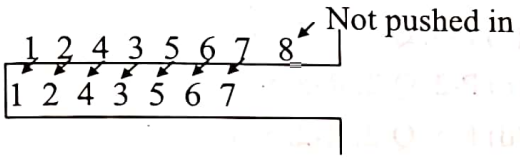
Sol: S_2, S_4 are correct

S_1, S_3 are incorrect

20. Ans: (d)

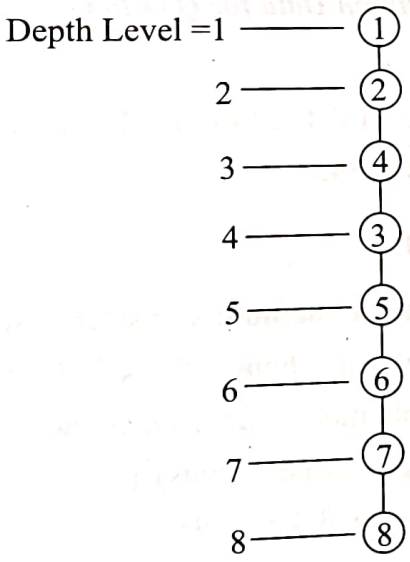
Sol:





21. Ans: 8

Sol:



22. Ans: (d)

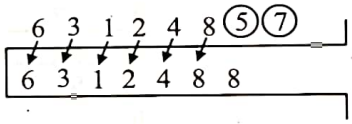
Sol: (a), (b), (c): valid

(d) Invalid because dequeued element '3' all adjacents are not explored.

23. Ans: (b)

24. Ans: (c)

Sol: Solution for **Q23 & Q24**



Q23: vertex 5 & 7 are not pushed in (above circled)

Q24: vertex 8 is pushed in stack for two times

25. Ans: (d)

Sol: In BFS, dequeued elements adjacents are enqueued first.

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Chapter 6 Hashing

01. A hash table with ten buckets with one slot per bucket is shown in the fig below, with the symbols S1 to S7 entered into it using some hashing function with **linear probing**. The worst case comparisons required when the symbol being searched is not in the table is

0	S7
1	S1
2	S8
3	–
4	S4
5	S2
6	S5
7	–
8	S6
9	S3

(a) 4
(b) 5
(c) 6
(d) 3

02. Keys 9,19,29,39,49,59,69 are inserted into the below table using hash function H = k mod 10 and **quadratic probing** is used for collision revolution. What is the index into which 59 will be inserted?

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

(a) 3
(b) 6
(c) 8
(d) 5

03. Match the following:

List-I

P: Linear probing
Q: Random probing
R: Quadratic probing
S: Separate chaining

List-II

1. Deletion possible
2. Secondary clustering
3. Deletion not possible
4. Overflow
5. Primary clustering

(a) P-5, Q-2, R-2, S-1
(b) P-5, Q-2, R-2, S-3
(c) P-2, Q-2, R-5, S-1
(d) P-5, Q-2, R-2, S-3

Common Data for Q04 to Q05

Data:

2245, 1374, 2145, 1401, 2145, 1621, 1444, 1996, 2345

Method:

Mid square method: Consider first 3 digits and square it and **choose 3rd, 4th, 5th** positions and then apply modulo division as shown below.

Hashing = {(first 3 digits)^2}

Mid Position 3,4,5 %19+1

04. How many collisions are there?

(a) 1 (b) 2 (c) 3 (d) 4

05. Collision Resolution = Random Number generator = (3 * address – 1) % 19 – 1

How many probes for key 199645?

(a) 1 (b) 2 (c) 3 (d) 4

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06. A hash table contains 1000 slots, indexed from 1 to 1000. The elements stored in the table have keys that range in value from 1 to 99999.Which, if any, of the following hash functions would work correctly?
(a) key MOD 1000
(b) (key - 1) MOD 1000
(c) (key +1) MOD 999
(d) (key MOD 1000) + 1

07. Consider the following data:
224562, 137456, 214562,
140145, 214576, 162145,
144467, 199645, 234534
Hash table size is 11.
Fold shifting method is used by folding two digits at a time and then modulo division of the folded sum, find how many collisions
(a) 1 (b) 2 (c) 3 (d) 4

08. Suppose that we have a data file containing records of famous people, and we need to build a hash table to find a record from the person's birthday. The size of the hash table is 4096. The following are hash functions which convert a birthday to an integer. Which function do you think is the best?
(a) h1(day/month/year)=day+ month + year
(b) h2(day /month / year) = day + month*31 + year
(c) h3(day/month/year)=(day + month*31 + year*365) mod 4096
(d) h4(day/month/year) = (day + month*31 + year*365) mod 4093

09. Suppose we are implementing quadratic probing with a hash table function Hash(x) = x mod 100. If an element with key 9999 is inserted and the first three locations attempted are already occupied, then the next call that will be tried is
(a) 99 (b) 8 (c) 4 (d) 3

10. Hash Table size = 13
Hash Function = H (x) = x mod 13
Collision Resolution = Quadratic probing
$= h + i^2$
Keys = 10, 100, 32, 45, 58, 126, 3, 29, 200, 400, 0, 21, 15.
Pickup the correct statement:
P: The Key '58' is stored at location: 10
Q: The Key '126' is stored at location: 9
R: The Key '0' is stored at location: 0
S: The Key '10' is stored at location: 11
T: The Key '15' is stored at location: 12
U: The Key '400' is stored at location: 10
V: The Key '29' is stored at location: 3
(a) P (b) V (c) R (d) T

11. How many collisions occur when the above keys are first folded by adding their digits together and then reducing to mod hash table size.
(a) 5 (b) 4 (c) 3 (d) 2

12. If linear probing is used for above key values, then how many probes are required to store 200
(a) 2 (b) 3 (c) 4 (d) 5

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13. Given the input {71, 23, 73, 99, 44, 79, 89} and a hash function h(x) = x mod 10 and quadratic probing, then in which location the last element is placed:

(a) 2 (b) 6
(c) 7 (d) 8

14. A hash function f defined as f(key)=key mod 7 with linear probing is used to insert the keys 37,38,72,48,98,11,56 into a table indexed from 0 to 6, what will be the location of key 11.

(a) 3 (b) 4
(c) 5 (d) 6

15. Consider a hash table of size FIVE, with starting index zero and a hash function (4x + 3) mod 5.

Assuming the hash table is initially empty, the keys 1, 3, 8, 10 and 4 are inserted into the table using closed hashing with linear probing.

In which location the last key is stored?

(a) 1 (b) 2
(c) 3 (d) 4

Linked Answer Questions (Q16 & Q17)

16. The keys 12, 18, 13, 2, 3, 23, 5 , 15 and 11 are inserted into an initially empty hash table of length 11 using open addressing with hash function h(k) = k mod 11 and Quadratic Probing with $h = h + i^2$ where i = 1, 2, 3, ...

What is the resultant hash table?

(a)

0	3
1	12
2	2
13	23
4	13
5	15
6	5
7	11
8	18
9	15
10	

(b)

0	
1	15
2	12
3	13
4	3
5	5
6	23
7	11
8	18
9	2
10	

(c)

0	
1	11
2	12
1	13
4	2
5	3
6	23
7	5
8	18
9	
10	

(d)

0	11
1	12
2	13
3	2
4	3
5	23
6	5
7	18
8	15
9	
10	

17. What is the index of the bin into which the record 29 is inserted?

(a) 7 (b) 8
(c) 9 (d) 10

18. Which of the following cases is a so-called "collision"?

(a) Two different hash functions produce the same address for a given key:
h1 (key) = h2 (key)

(b) Two different hash functions produce the same address for two different keys:
h1 (key1) = h2(key2)
where key1 = = key2

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(c) A hash function produces the same address for two different keys:
h (key1) = h (key2)
where key1 = = key2

(d) A hash function produces the same address for two keys of the same length:
h(key1) = h(key2)
Where length (key1) = length (key2)

19. A hash table with chaining has been defined in which each entry is initialized to false. A program that checks spelling works in the following way. A hash function has been applied to each word in the dictionary and the appropriate entry in the hash table has been set to true. To check the spelling in a document, the hash function is applied to every word in the document and the appropriate entry in the hash table is examined. Which of the following is (are) *correct*?

S1: Hash table should increase with document size

S2: True means the word was in the dictionary

S3: False means the word was not in the dictionary

(a) S1, S2, S3 (b) S2, S3
(c) S3 (d) S2

20. **Assertion (a):** Primary clustering is taking place in the linear of Hashing.

Reason (r): All collided records are probing into same location.

Choose:

(a) Both (a) & (r) are true and (r) is the correct explanation for (a).
(b) Both (a) & (r) are true and (r) is not the correct explanation for (a).
(c) (a) is true and (r) is false.
(d) (a) and (r) are false.

Common Data for Q21 & Q22

999, 888, 777, 666, 555, 444, 333, 222, 111, 987, 786, 200 and hash table size =13

21. How many collisions occur when these keys are first folded by adding their digits together and then reducing to mod hash table size?

(a) 1 (b) 2
(c) 3 (d) 4

22. In the above problem, if linear probing is used then how many probes are required to store 200?

(a) 2 (b) 3
(c) 4 (d) 5

Common Data for Questions 23 and 24:

211, 224, 271, 254, 213, 214, 222, 243,136, 192, 286

A sequence of records with the above keys are inserted into an initially empty hash table, the bins of which are indexed from zero to ten. The above records are first folded by adding their individual digits and then narrow down to hash table of size 11.

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23. If linear probing is used, then how many probes are required to store the last record 286?

(a) 0 (b) 1

(c) 2 (d) 3

24. If random probing with $y_{new} = (y_{old}+4) \bmod 11$ is used, then what is the index of the bin into which the last record is inserted?

(a) 0 (b) 1

(c) 2 (d) 3

25. **Assertion (A):** Quadratic probing is better than Linear Probing of hashing.

Reason (R): In Quadratic Probing, all buckets are NOT compared

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

26. A hash function h defined as $h[k] = k \bmod 10$, with linear probing is used to store the following keys 44,45,79,55,91,18,63 and 11. What will be location of the last record?

(a) 2 (b) 4

(c) 6 (d) 1

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Solutions

01. Ans: (c)

Sol: The symbol is compared the 8, 9, 0, 1, 2 and 3 location values. At 3rd location it will be stopped because it is empty.

02. Ans: (b)

Sol:

0	19
1	
2	
3	39
4	29
5	49
6	59
7	
8	
9	9

$H = k \bmod 10$

If collision $H = (H + i^2) \bmod 10$

$H = 9 \bmod 10 = 9$

$H = 19 \bmod 10 = 9$ collision

$9 + 1^2 \bmod 10 = 0$

$H = 29 \bmod 10 = 9$ collision

$9+1^2 \bmod 10=0+2^2=4 \bmod 10=4$

$H = 39 \bmod 10 = 9$ collision

$(9 + 1^2) \bmod 10 = 0$ collision

$(0 + 2^2) \bmod 10 = 4$ collision

$(4 + 3^2) \bmod 11 = 3$

$H = 49 \bmod 10 = 9$ collision

$9 + 1^2 \bmod 10 = 0$ collision

$0 + 2^2 \bmod 10 = 4$ collision

$4 + 3^2 \bmod 10 = 3$ collision

$3 + 4^2 \bmod 10 = 9$ collision

$9 + 5^2 \bmod 10 = 4$ collision

$4 + 6^2 \bmod 10 = 0$ collision

$0 + 7^2 \bmod 10 = 9$ collision

$9 + 8^2 \bmod 10 = 3$ collision

$3 + 9^2 \bmod 10 = 4$ collision

$4 + 1^2 \bmod 10 = 5$

$H = 59 \bmod 10 = 9$ collision

$9 + 1^2 \bmod 10 = 0$ collision

$0 + 2^2 \bmod 10 = 4$ collision

$4 + 3^2 \bmod 10 = 3$ collision

Continue – (see above H)

$4 + 1^2 \bmod 10 = 5$ collision

$5 + 2^2 \bmod 10 = 0$ collision

$0 + 3^2 \bmod 10 = 9$ collision

$9 + 4^2 \bmod 10 = 5$ collision

$5 + 5^2 \bmod 10 = 0$ collision

$0 + 6^2 \bmod 10 = 6$

03. Ans: (a)

Sol: Linear Probing → primary Clustering

$H + 1, H + 2 + \ldots H + m - 1.$

Random probing, Quadratic probing Secondary clustering

Separate chaining – Deletion possible

04. Ans: (a)

Sol: Square of first 3 digits

Square of first 3digits	3rd,4th,5th positions %19+1
224 * 224 = 50176	176 % 19+1 = 6
137 * 137 = 18769	769 % 19+1 = 10
214 * 214 = 45796	796 % 19+1 = 18 *
140 *140 = 19600	600 % 19+1 = 12
214 * 214 = 45796	796%19+1=18*collision 1
162 * 162 = 26244	244 % 19+ 1 = 17
144 * 144 = 20736	736 % 19+1 = 15
199 * 199 = 39601	601 % 19+1 = 13
234 * 234 = 54756	756 % 19+1 = 16

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05. Ans: (b)

Sol: 601% 19 + 1 = 13 * collision

Collision Resolution = (3 * 13 – 1) % 19 –1

= –1 mod 19 = 18

13 + 18 mod 19 = 12 * collision

Collision Resolution = (3*12 –1) %19–1= 15

12 +15 mod 19 = 8 no collision

key = 199645

square of first 3 digits

199 *199 = 39601

06. Ans: (d)

1000 slots indexed from 1 to 1000

1000 slots means modulo must be 1000 and index is from 1 to 1000, the hash function must (key mod 1000) + 1

07. Ans: (a)

Sol: **Fold shifting Method:**

224562 ⇒ (22 + 45 +62) % 11 = 8

140145 ⇒ (14 + 01 + 45) % 11 = 5

144467 ⇒ (14 + 44+ 67) % 11 = 4

137456 ⇒ (13 + 74 + 56) % 11 = 0

214576 ⇒ (21 + 45 + 76) % 11 = 10

199645 ⇒ (19 + 96 + 45) % 11 = 6

214562 ⇒ (21 + 45 + 62) % 11 = 7

162145 ⇒(16+ 21 + 45) % 11

= 5 * collision

234534 ⇒ (23+45+34) % 11 = 3

1 collision

08. Ans: (c)

Sol: Convert month and year into days then apply modulo 4096 because size of hash table is 4096.

09. Ans: (b)

Sol: h(9999)=9999 %100=99*collision occupied

h(9999) =(99+1^2) mod 100=0 * occupied. (quadratic probing)

h(9999) = (99 +2^2) mod 100 = 3 * occupied

h(9999) = (99 + 3^2) mod 100 = 8

8 location is tried next

10. Ans: (d)

Sol: 10 mod 13 = 10

100 mod 13 = 9

32 mod 13 = 6

45 mod 13 = 6 * collision

Collision Resolution = 6 +1^2 = 7

58 mod 13 = 6 * collision

Collision Resolution = 6 +1^2 = 7 * collision

6 + 4 = 10 * collision

6 + 3^2 = 15 mod 13 = 2

126 mod 13 = 9 * collision

Collision Resolution

= 9 +1^2 = 10 * collision

9 + 2^2 = 13 mod 13 = 0

3 mod 13 = 3

29 mod 13 = 3 * collision

Collision resolution = 3 + 1 = 4

200 mod 13 = 5

400 mod 13 = 10 * collision

Collision resolution = 10 + 1^2 = 11

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0 mod 13 = 0 * collision
Resolution = 0 + 1 = 1
21 mod 13 = 8
15 mod 13 = 2 * collision
Collision Resolution = 2 + 1 = 3 * collision
$2 + 2^2 = 6$ * collision
$3 + 3^2 = 11$ * collision
$2 + 4^2$ mod 13 = 5 * collision
$2 + 5^2$ mod 13 = 1 * collision
$2 + 6^2$ mod 13 = 12

11. Ans: (a)

Sol: 10 = 1 + 0 = 1
100 = 1 + 0 + 0 = 1 * collision
32 = 3 + 2 = 5
45 = 4 + 5 = 9
58 = 5 + 8 = 13 mod 13 = 0
126 = 1 + 2 + 6 = 9 * collision
3 = 3
29 = 2 + 9 = 11
200 = 2 + 0 + 0 = 2 * collision
400 = 4 + 0 + 0 = 4
0 = 0 * collision
21 = 2 + 1 = 3 * collision
15 = 1 + 5 = 6

12. Ans: (a)

Sol: From above hash values apply linear probing
10 → 1
100 → 1 collision →1+1 (linear probing) = 2
32 → 5
45 → 9
58 → 0
126 → 9 → 9 + 1 (linear probing) = 10
3 → 3
29 → 11
200 → 2 * collision (linear probing)
2 + 1 = 3 * collision
2 + 2 = 4

13. Ans: (d)

Sol:

x	h(x) = x%10
71	1
23	3
73	3 * collision

Quadratic probing = $h+i^2$%10 = 3 + 1 = 4

99	9
44	4 * collision

Quadratic probing = 4+1% 10 = 5

79	9 * collision

Quadratic probing = 9+1%10 = 0

89	9 * collision

Quadratic probing = 9+1%10
= 0 * collision
$9+2^2$ = 13%10=3 * collision
$9+3^2$ = 18%10 = 8
89 is placed 8th location

14. Ans: (c)

Sol:

Key	Hash	Linear probing if collides
37	37 % 7 = 2	
38	38 % 7 = 3	
72	72 % 7 = 2 * collision	2+1= 3* Collision 3+1=4
48	48 % 7 = 6	
98	98 % 7 = 0	
11	11 % 7 = 4 * collision	4+1 = 5

11 is stored at 5

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15. Ans: (d)

Sol:

Keys	hash	Linear probing
1	7 mod 5 = 2	
3	15mod 5 = 0	
8	35 mod 5 = 0*collision	0+1=1
10	43mod 5 = 3	
4	19mod 5 = 4	

16. Ans: (d)

Sol:

0	11
1	12
2	13
3	2
4	3
5	23
6	5
7	18
8	15
9	
10	

12 mod 11 = 1
18 mod 11 = 7
13 mod 11 = 2
2 mod 11 = 2 * collision
Quadratic probing = $h + i^2$ mod 11
= 2 + 1 = 3
3 mod 11 = 3 * collision
Quadratic probing = 3 + 1 = 4
23 mod 11 = 1 * collision
Probing 1 + 1 = 2 * collision
$1 + 2^2 = 5$
5 mod 11 = 5 * collision
Probing 5 + 1 = 6
15 mod 11 = 4 * collision
Probing 4 + 1 = 5 * collision
$4 + 2^2 = 8$
11 mod 11 = 0

17. Ans: (d)

Sol: 29 mod 11 = 7 * collision

Probing 7 +1 = 8 * collision

$7 + 2^2 = 11$ mod 11 = 0 * collision

$7 + 3^2 = 16$ mod 11 = 5 * collision

$7 + 4^2 = 23$ mod 11 = 1 * collision

$7 + 5^2 = 32$ mod 11 = 10

29 is placed at 10.

18. Ans: (c)

Sol: Collision occurs when two different keys produces same hash value.

19. Ans: (d)

Sol: S_1 and S_3 are false

S_2 is correct.

20. Ans: (a)

Sol: Collided records are probed into same location.

21. Ans: (c)

Sol:

Key	First fold by adding digits	Hash
999	9+9+9 = 27	27% 13 = 1
888	8 + 8 + 8 = 24	24% 13 = 11
777	7 + 7 + 7 = 21	21% 13 = 8
666	6 +6 + 6 = 18	18% 13 = 5
555	15	15% 13 = 2
444	12	12% 13 = 12
333	9	9
222	6	6
111	3	3
987	9 + 8 + 7 = 24	24% 13 = 11 *collision
786	21	21% 13 = 8 * collision
200	2	2 * collision

22. Ans: (c)

Sol: collisions are 987, 786, 200

↓ ↓ ↓

Hash 11 8 2

Linear probing 987

11 + 1 = 12 * collision

Linear probing 786

8 + 1 = 9 * collision

8 + 2 = 10

Linear probing 200

2 + 1 = 3 * collision

2 + 2 = 4

1 probing for 200

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23. Ans: (a)

Sol:

Key	First fold by addition	Hash	Linear Probing
211	2 + 1 +1 = 4	4	
224	2 + 2 + 4 = 8	8	
271	2 + 7 +1 = 10	10	
254	2 + 5 + 4 = 11	0	
213	2 + 1 + 3 = 6	6	
214	2 + 1 + 4 = 7	7	
222	2 + 2 + 2 = 6	6 * collision	6+ 1 = 7 * collision 6 +2 = 8 *collision 6 + 3 = 9
243	2 + 4 + 3 = 9	9 * collision	9 + 1 = 10 * collision 9 + 2 = 11 * collision 9 + 3 = 1
136	1 + 3 + 6 = 10	10 * collision	10 + 1= 0 * collision 10 + 2= 1 * collision 10 + 3 = 2
192	1 + 9 + 2 = 12	1 * collision	1 +1 = 2 * collision 1+ 2 = 3
286	2 + 8 + 6 = 16	5	

0	254
1	243
2	136
3	192
4	211
5	286
6	213
7	214
8	224
9	222
10	271

0 probes (no collision)

24. Ans: (b)

Sol: Upto 214 there are no collision from above data.

hash(222) = 6 * collision

probing

$hash_{new}$ = (6+4) mod 11 = 10 * collision

$hash_{new}$ = (10 + 4) mod 11 = 3

hash(243) = 9

hash(136) = 10 * collision

$hash_{new}$ = 10 + 4 mod 11 = 3 * collision

$hash_{new}$ = 3 + 4 mod 11 = 7 * collision

$hash_{new}$ = 7 + 4 mod 11 = 0 * collision

$hash_{new}$ = 0 + 4 = 4 * collision

$hash_{new}$ = 4 + 4 = 8 * collision

$hash_{new}$ = 8 + 4 = 12 mode 11 = 1

hash (192) = 1 * collision

Random probing $hash_{new}$= $hash_{old}$+4 mod 11

= 1 + 4 = 5

hash (286) = 5 * collision

$hash_{new}$ = 5 + 4 = 9 *collision

= 9 + 4 = 13 mod 11 = 2

286 requires 1 probing

25. Ans: (d)

Sol: **(A):** Quadratic probing is better than Linear Probing of hashing – is wrong because LP is better than QP since all buckets are compared.

(R): In Quadratic Probing, all buckets are NOT compared – True.

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26. Ans: (a)

Sol: h[k]=k mod 10

key:	44	45	79	55	91	18	63	11
loc:	4	5	9	5	1	8	3	1

0	
1	91
2	11
3	63
4	44
5	45
6	55
7	
8	18
9	79

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Programming Languages

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Programming Languages

01. int main( )

```
{
    printf ("%d", printf("Hi!") *printf ("Bye"));
    return (0);
}
```

What is the output for the above program?

(a) Bye Hi! 6 (b) Hi! Bye 9

(c) Hi! Bye (d) None of these

02. int main( )

```
{
  int m = 10, n = 20;
  printf("%d  %d  %d",  m  /*m-value*/,
  /* n–value */n,  m /* compute m*n */n);
  return (0);
}
```

What is the result?

(a)Runtime Error (b) 10 20 20

(c) Compile-Time Error (d) 10 20 200

03. int main( )

```
{
    char str[ ] = "Test";
    if ((printf ("%s", str)) = = 4)
            printf ("success");
    else
            printf( "Failure");
    return (0);
}
```

(a) Failure (b) Success

(c) Compile-Time Error (d) Test

04. int main ( )

```
{
    int val = 5;
    printf ("%*d", val, val);
    return(0);
}
```

(a) bbbbb5 (Where b means blank space)

(b) 5

(c) Compile Time Error

(d) None of these

05. A language with string manipulation facilities uses the following operation head (S) : first character of a string, tail (S): all but the first character of a string, Concat (S_1, S_2): S_1S_2 For the string acbc what will be the output of Concat (head (S), head(tail(tail(S))))

(a) ac (b) bc

(c) ab (d) cc

06 Structures in 'C' support

I. Call by Value

II. Call by address

(a) Only I (b) Only II

(c) Both I and II (d) None

07 What would be the output of the following programs.

I. main ( )

```
{
  printf("\n%d%d%d",sizeof('3'),sizeof("3"),
        sizeof (3));
}
```


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```
II. main ( )
  {
   printf("\n %%%%");
  }
```

(a) I. 111 II. %%% (b) I. 222 II. %%%
(c) I. 122 II. %%% (d) I. 111 II. %%%%

08. What do the following declaration signify?
char (*(*X[3]) ( ))[5];
(a) X is a pointer to an array of 3 elements function returning an array of 5 pointers
(b) X is a pointer to an array of 3 elements which returns an array of 5 chars
(c) X is an array of 3 pointers to function returning pointer to an array of 5 chars
(d) None of these

09. Match the following

P. int main ( ) { printf( ); return(0); }	1. Run-time Error
Q. int main ( ) { printf (NULL); return (0); }	2. Compile- Time Error
R. int main ( ) { printf("%d", printf(" ") + printf(" ")); return (0); }	3. No output
	4. 0
	5. None of these

(a) P-1, Q-2, R-3 (b) P-4, Q-4, R-2
(c) P-2, Q-3, R-4 (d) P-5, Q-2, R-2

Data for Q10 and Q11 are given below. Solve the problems and choose correct answer

Consider the following program

```
int x = 10;
main ( )
{
        p(x);
        print (x);
}
p (int a)
{
        if ( a ≤ 40)
        {
                a = a+10;
                p(a);
                x = a + 10;
        }
}
```

10. What value is printed if the program uses "Call by Value"?
(a) 30 (b) 60
(c) 90 (d) 50

11. What value is printed if the program uses "Call by Reference"?
(a) 30 (b) 60
(c) 90 (d) 50

12. Macro processing is done during
(a) compile time (b) load time
(c) runtime (d) link time

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13. _____ is a num type for which we can define the operations to be used for manipulating instances, while the data structure that implements the type is hidden to the users.
(a) Primitive data type
(b) Based-data type
(c) Abstract data type
(d) Object-data type

14. Which of the following is ***not*** a valid declaration for main( )?
(a) int main( )
(b) int main (char * arg c[ ], int arg v)
(c) int main (int arg v, char * arg v [ ])
(d) a, b & c are correct

15. After a function has returned, the values stored in its local variables are copied into variables in the main function with the same name
(a) True (b) False
(c) can't say (d) error

16. Consider the following statements:
I. The *l* – value of a variable is the storage area bound to the variable during execution.
II. The r – value of a variable is the encoded value stored in the location associated with the variable.
III. Some languages allow variables that can be accessed through the r – value of another variable known as reference.
Which of the above statements are ***false***?
(a) I & II (b) II & III
(c) I, II & III (d) none of the above

17. Match the following:

(1) C	(M) Imperative
(2) Java	(N) Functional
(3) Lisp	(O) Object oriented
(4) Prolog	(P) Constraint based

Codes:
(a) 1 – M, 2 – N, 3 – O, 4 – P
(b) 1 – P, 2 – O, 3 – M, 4 – N
(c) 1 – M, 2 – P, 3 – O, 4 – N
(d) 1 – M, 2 – O, 3 – N, 4 – P

18. Consider the following 'C' statement. What is the order in which functions are called?
a = f1 (23, 14) * f2 (12/4) + f3( );
(a) f1, f2, f3
(b) f3, f2, f1
(c) The order may vary from compiler to compiler
(d) None of the above

19. In which of the following parameter passing mechanisms, the actual argument has to be a variable.
(a) call by value
(b) call by name
(c) call by reference
(d) call – by – need

20. The period of time between an allocation and its subsequent disposal is called
(a) Scope (b) life time
(c) Binding (d) longevity

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21. Which of the following is a dangling reference?
(a) Accessing a storage that is already disposed at the request of the user.
(b) Accessing a storage that is already disposed at the request of the processor.
(c) Accessing a variable that is declared but not initialized
(d) None of these

22. Consider the following program segments:

```
char *a, *b, c[10], d[10];
a = b ; / * line 1 * /
b = c ; / * line 2 * /
c = d ; / * line 3 * /
d = a ; / * line 4 * /
```

Which of the following have errors?
(a) line 1 (b) line 2
(c) line 3 and line 4 (d) none has errors

23. The use of macro in the place of functions:
(a) reduces execution time and code size
(b) increases execution time and reduces code size
(c) increases execution time and increases code size
(d) reduces execution time and increases code size

24. A function 'q' that accepts a pointer to a character as argument and returns a pointer to an array of integer can be declared as
(a) int *(*q(char*)) [ ]
(b) int *q(char*)[ ]
(c) int (*q) (char*) [ ]
(d) none of these

Common Data for Q25 & Q26

Consider the following program fragment :

```
Procedure Exchange(A : integer, B : integer)
begin
    temp : integer;
    temp = A;
    A = B;
    B = temp;
end;
begin
    m = 2 ; x[m] = 4 ;
    Exchange(m, x[m]) ;
    write(m, x[2]) ;
end ;
```

25. If the parameters are passed by value, the output will be
(a) 2, 4 (b) 4, 2 (c) 2, 2 (d) 4, 4

26. 4, 2 will be the output if the parameters are passed by
(a) reference (b) name
(c) value (d) none

27. What does the following declaration specify?
Char * (*P) (int * a, int (* b) [3])
(a) 'P' is a pointer to a character return pointer to an integer & accepting pointer to 'b' with 3 elements.
(b) 'P' is a function pointer return pointer to an integer and accepting pointer to an array with 3 elements.
(c) 'P' is a function pointer returning pointer to a character and accepts an integer pointer and integer pointer to an array with 3 elements.
(d) There is an error in the declaration.

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28. Consider the program given below:

```
main ( )
{
    int c [ ] = { 2, 8, 3, 4, 4, 6, 7, 5};
    int j, *p = c, *q = c;
    for (j = 0; j < 5; ++j)
    {
        printf ("%d", *c);
        ++q;
    }
}
```

What is the output of the program?

(a) 2 2 2 2 2
(b) 2 3 4 7 5
(c) 2 2 2 2 3
(d) 2 3 4 4 6

29. Consider the program below:

```
main ( )
{
    struct KRK
    {
        int x = 3;
        char name [ ] = "Hello";
    };
    struct KRK *p;
    printf ("%d", p → x);
    printf ("%s", p → name);
}
```

What is the output of the program?

(a) 3 Hello
(b) junk output
(c) 3 garbage value
(d) Compiler error

Common Data for Q30 & Q31 is given below:

Consider the program given below:

```
main ( )
{
    integer x;
    x = 5;
    P(x);
    Q(x);
    print (x);
}

Q (integer z)
{
    z = z +x;
    print (z);
}
P (integer y)
{
    integer x;
    x = y+2;
    Q(x);
    print(x);
}
```

30. What is the output of the program, when the parameter passing mechanism is call by reference and the dynamic scoping is used?

(a) 12, 7, 10, 5
(b) 14, 14, 10, 10
(c) 14, 7, 10, 5
(d) 12, 12, 10, 10

31. What is the output of the program, considering call by value and dynamic scoping?

(a) 12, 12, 10, 10
(b) 14, 7, 10, 5
(c) 14, 14, 10, 10
(d) 12, 7, 10, 5

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32. The object – oriented paradigm includes which of the following properties?

I. Encapsulation

II. Inheritance

III. Recursion

IV. Rule – based evaluation

(a) I & II (b) I, II, III

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

33. Consider the following pseudo code

```
x = 1;
y = 1;
while (x ≤ 1000)
{
        x = 2^x;
        i = i + 1;
}
```

What is the value of 'i' at the end of the pseudo code?

(a) 4 (b) 7

(c) 5 (d) 8

34. Consider the following statements:

I. With dynamic scope complete type checking can not be performed until runtime.

II. Dynamic scope is used by languages such as C & C ++.

III. Use of dynamic type checking, instead of static type checking allows faster Program execution.

Which of them is/are true?

(a) I Only (b) I & II

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

35. In a system with automatic memory management, a garbage collector typically has the responsibility for reclaiming allocated memory chunks whose contents cannot affect legal computation. Such objects are identified by determining that they cannot be reached from a root set, which of the following is ***NOT*** part of the root set in a typical garbage collector?

(a) Actual parameters of the active procedures.

(b) Dynamically allocated objects on the heap.

(c) Global variables of the program.

(d) Values in machine registers.

Common Data for Q36 & Q37 is given below.

Consider the program given below with procedures P_1, P_2, P_3. The main program call procedures P_1, P_1 calls P_3, and P_3 calls P_2.

```
program main;
    i : integer;
    procedure P1( )
    {       i : integer;
            procedure P2( )
            {
                    write (i);
            }
            procedure P3( )
            {       i : integer;
                    i = 5;
                    P2 ( );
            }
            i = 7;
            P3( );
    }
    main ( )
    {       i = 3;
            P1 ( );
    }
```


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36. What will be printed by the program if it uses static scoping to resolve the free variables?
(a) 7 (b) 5
(c) 6 (d) none of these

37. What if in program of question 36, uses dynamic scoping?
(a) 7 (b) 5
(c) 6 (d) none of these

38. Structures in C/C++ Support:
I. Call – by – Value
II. Call – by – Reference
III. Call – by – Name
IV. Call – by – Text
(a) I, II, III (b) II, III
(c) II only (d) I & II

39. Consider the following program:

```
Program main
x : integer ;
Procedure Sub1
begin
    write (x) ;
end
Procedure Sub2
  x : integer;
begin
  x = 10;
  Sub1;
end
begin
  x = 10 ;
  sub1;
end
begin
   x = 5 ;
   sub2 ;
end
```

What is the output of the program under static & Dynamic scoping?
(a) 10, 5 (b) 10, 10
(c) 5, 5 (d) 5, 10

40. Which of the following is a logic / constraint based language?
(a) LISP (b) Small talk
(c) C (d) Prolog

41. A certain computer architecture supports only the immediate and the direct addressing modes. Which of the following programming language features cannot be implemented on this processor?
(a) Pointers
(b) Arrays
(c) Records
(d) Recursive procedures with local variable

42. Consider the following program segment of a hypothetical high – level programming language.

```
x, y : integer ;
Procedure A(z : integer)
x : integer ;
begin
        x = 1;
        B ;
        z = x ;
end ;
Procedure B ( )
begin
        x = x+1;
end;
```


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```
begin { main }
        x = 5 ;
        A (y) ;
        Write (y) ;
end ;
```

Assuming the parameter 'z' is passed by reference and the language uses dynamic scoping, what is the output of the program.

(a) 5 (b) 6 (c) 7 (d) 2

43. Consider the following program segment

```
integer x;
procedure Q(z: integer)
begin
        z = z+x;
        Print (z);
end

procedure P(y: integer)
        x: integer
begin
        x = y+2;
        Q(x);
        Print (x);
end;
begin {main}
        x=5;
        P(x);
        print(x);
end
```

What is the output of the program with call by reference parameter passing & dynamic scoping rule?

(a) 14, 14, 5 (b) 7, 14, 5
(c) 14, 7, 5 (d) 14, 14, 14

44. What is the output of the following C program:

```
int f(int x, int xy, int xxz)
{
        int k, m;
        **z + = 2;
        m = **z;
        *y+ = 1;
        k = *y;
        x+ = 5;
        return (x+k+m);
}
main( )
{
        int i = 10, *b, **a, t ;
        b = &i;
        a = &b;
        t= f(i,b,a);
        printf("%d", t);
}
```

(a) 32 (b) 35
(c) 38 (d) 40

45. Program A;

```
X: procedure (int x)
{
    int y;
    y = x + 1;
    return;
}
main( )
{
    X (3);
    print x, y;
}
```


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The above program has the output, when x, y called by value

(a) 3, 4
(b) 4, 3
(c) undefined
(d) none of the above

46. What would be the output of the following program?

```
Unsigned int n=20,i;
main( )
{
    for(i=0;i<n;i--)
    printf("b");
}
```

(a) infinite number of b's
(b) 20 b's are printed
(c) 65537 b's are printed
(d) none

47. Which of the following is an advantage of static scoping?

(a) Readability (b) Predictability
(c) Type checking (d) All of the above

48. What is the output printed by following program?

```
int main ()
{
    if ( 0 < 7 < 5)
        printf ( "I am printed") ;
    else
        printf ( "I am not printed ") ;
}
```

(a) I am printed (b) I am not printed
(c) Compiler error (d) None of these

49.
```
void main( )
{
    int A[10][20];
    int i,j , *p;
    p=&A[0][0];
    for(i=0;i<20;i++)
    for(j=0;j<10;j++)
    *(p+20*j+i)=i*20+j;
    printf("%d", A[5][10] – A[5][9]);
}
```

value printed by the program is

(a) 1 (b) 10
(c) 20 (d) 100

50. Which of the following statements is false about recursion?

(a) Simplifies the logic
(b) Every recursive program can have an alternative iterative program
(c) Generally recursive version of programs take less space over iterative counter parts
(d) None of these

51.
```
#define swap1(a, b)
a=a + b; b=a – b; a=a – b;
void main( )
{
    int x=5,y=10;
    swap1(x,y);
    printf("%d %d \n", x,y);
    swap2(x,y);
    printf("%d %d \n", x,y);
}
```


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```
int swap2(int a, int b)
{
        int temp;
        temp=a;
        b=a;
        a=temp;
}
```

What is the output of the above program?

(a) 10 5
5 10

(b) 10 5
10 5

(c) 5 10
10 5

(d) 5 10
5 10

52.
```
void myfunc(int x)
{
    if(x>0)
    myfunc(– – x);
    printf("%d", x);
}
```

What is the output of the f(4)?

(a) 2, 3, 4, 5, 5

(b) 4, 3, 2, 1, 0

(c) 0, 1, 2, 3, 4

(d) 0, 0, 1, 2, 3

53. Consider the following C code

```
int i=0;
main()
{
    int i=1;
    printf("%d ",i);
    {
        int i =2;
        printf("%d  ",i);
        {
            i=i+1;
            printf("%d ",i);
        }
        printf("%d ",i);
    }
    printf("%d",i);
}
```

What does the program print?

(a) 1 2 3 3 1

(b) 1 0 1 2 2

(c) 1 2 3 3 2

(d) Compilation error

54. Consider the following program segment of a hypothetical high – level programming language.

```
        x, y : integer;
Procedure A(z : integer)
        x : integer;
        begin
                x = 1;
                B ;
                z = x;
        end;
Procedure B( )
        begin
                x = x+1;
        end;
        begin {main}
                x = 5;
                A (y);
        write (y);
        end;
```

Assuming the parameter 'z' is passed by reference and the language uses dynamic scoping, what is the output of the program.

(a) 5

(b) 6

(c) 7

(d) 2

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55. What is the output of the following C program:

```
int f(int x, int xy, int xxz)
{
        int k, m;
        **z + = 2;
        m = **z;
        *y+ = 1;
        k = *y;
        x+ = 5;
        return (x+k+m);
}
main( )
{
        int i = 10, *b, **a, t ;
        b = &i;
        a = &b;
        t= f(i,b,a);
        printf("%d", t);
}
```

(a) 32
(b) 35
(c) 38
(d) 40

56. Consider the following 'C' program segment:

```
char *c[ ]={"MOCKGATE", "GATE2012"};
char **P;
P = c;
printf("%S", P[1] + 2);
```

What is the output of the program?

(a) MOCKGATE
(b) CKGATE
(c) E2012
(d) TE2012

57.

```
void abc( int x, int y)
{
        printf("%d %d", x,y);
}
void main( )
{
        int a;
        a = 10;
        abc(++a, a++);
        printf("%d",a);
}
```

The output of the above program is

(a) 12, 10, 12
(b) 11, 11, 12
(c) 11, 12, 12
(d) 12, 12, 12

58.

```
void main ( )
{
        static int S = 1;
        ++S;
        printf("%d", S);
        if( S <= 3)
        main( );
        printf("%d", S);
}
```

What is the output of the above program?

(a) 2, 2, 3, 4, 4, 4
(b) 2, 2, 3, 3, 4, 4
(c) 2, 3, 4, 4, 4, 4
(d) Stack overflow ERROR

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Common Data for Questions 59 & 60:

Consider the following program in a language with static scope.

```
Program main( input, output);
  var i, j, k : integer;
  procedure Q( var i : integer, m : integer)
        begin
            i : = i + k;
            m : = j + 1;
            writeln (i, j, k, m);
        end;
  cedure P(var i : integer; j : integer);
        var k : integer;
        begin
            k : = 4;
            i : = i + k;
            j : = j + k;
            Q(i, j);
        end;
        begin
            i : = 1;
            j : = 2;
            k: = 3;
            P(i, k);
        end
```

59. What is the output printed by writeln statement if the parameter passing mechanism is call by value?

(a) 8, 2, 3, 3 (b) 1, 2, 3, 7
(c) 5, 2, 3, 7 (d) 5, 7, 4, 7

60. What is the output printed by writeln statement if the parameter passing mechanism is call by reference?

(a) 1, 2, 3, 3 (b) 5, 7, 3, 3
(c) 12, 2, 3, 3 (d) 12, 2, 3, 7

61.
```
extern int g;
void abc( )
{
        ++g;
}
void main()
{
        ++g;
        abc( );
        printf("g=%d", g);
}
```

What is the output of the above program?

(a) 2 (b) 1
(c) 0 (d) linking error

62. Write the C-statement for the following declaration

"Function 'f' returns a pointer to an array of pointers to a function return a character"

(a) char (*(*f())[ ])();
(b) char (*(*f())) ();
(c) char * (*(*f()))();
(d) char * (*(*f())[ ])();

63. Consider the following function:

```
void test_b(int n)
{
        if (n>0)
        test_b(n – 2);
        printf ("%d", n );
}
```


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What is printed by the call test_b(4) ?

(a) 0 2 4 (b) 0 2

(c) 2 4 (d) 4 2 0

Common Data for Q64 and Q65 is given below.

Consider the following program:

```
double Do( double X, long int n)
{
    double A;
    if ( n = = 1)
    return X;
    A = Do( X, n/2);
    if (n % 2)
    return X * A * A;
    return A*A;
}
```

64. What does DO do?

(a) X^n (b) n^X (c) X^{n+1} (d) n^{X+1}

65. How many number of multiplications are taking place if X = 2 and n = 37?

(a) 37 (b) 36 (c) 7 (d) 6

66. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
        int i=10;
        i==50;
        if(i==50)
        printf("i is fifty\n");
        else
        printf("i is not fifty\n");
        return 0;
}
```

(a) i is fifty

(b) i is not fifty

(c) Compile time error

(d) No output

67. What is the output of the following program?

```
int main(void)
{
    int a=20,b=3;
    if(a<10)
    a=a–5;
    b=b+5;
    printf("%d  %d\n",a,b);
    return 0;
}
```

(a) 20 8 (b) 21 9

(c) 20 9 (d) 21 10

68. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
        int i=1, j=9;
        if(i>=5 && j<5);
        i = j+2;
        printf("%d\n", i);
        return 0;
}
```

(a) 12 (b) 10

(c) 11 (d) 15

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69. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int a=0,b=0;
  if(!a)
  {
        b = !a;
        if(b)
        a = !b;
  }
  printf("%d, %d\n", a, b);
  return 0;
}
```

(a) 1, 0 (b) 0, 1
(c) 1, 1 (d) 0, 0

70. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
        int a=2,x=10;
        if(a==2)
        if(x==8)
                printf("a is 2 and x is 8\n");
        else
                printf("a is not 2\n");
        return 0;
}
```

(a) a is 2 and x is 8 (b) a is not 2
(c) 18 (d) None of these

71. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int k=10;
  switch(k)
  {
        case '5':
        case '10':
                k++;
                continue;
        case '15':
        case '20':
                k--;
  }
  return 0;
}
```

(a) 10 (b) 11
(c) Error (d) No output

72. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int var=2,x=1,y=2;
  switch(var)
  {
        case x:
            x++;
            break;
        case y:
            y++;
            break;
  }
  return 0;
}
```

(a) 3 (b) 2 (c) 4 (d) Error

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73. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int i, total=0;
  for(i=1; i<=10; i++)
  {
        switch(i)
        {
              case 1:
              case 4:
              case 5:
              case 7:
                    total+=i;
                    break;
              default:
                    continue;
        }
        printf("%d\t",i);
  }
  printf("total=%d\n", total);
  return 0;
}
```

(a) 1 4 5 7 total = 17

(b) 1 5 4 7 total = 15

(c) 1 7 5 4 total = 14

(d) 5 4 7 1 total = 17

74. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{ int x=2,y=20;
  switch(x)
  {
              y=30;
    case 1:
              y++;
              break;
    case 2:
              y--;
              break;
    default:
              y=y+2;
  }
  printf("y is %d\n",y);
  return 0;
}
```

(a) y is 20 (b) y is 19

(c) y is 17 (d) y is 18

75. What is the output of the following program?

```
/*(i)*/
#include<stdio.h>
int main(void)
{       int a=5;
        begin:
        if(a)
        {
              printf("%d\t",a);
              a--;
              goto begin;
        }
        return 0;
}
```


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```
/*(ii)*/
#include<stdio.h>
int main(void)
{
        int a=5;
        begin:
        if(a)
        printf("%d ",a);
        a--;
        goto begin;
        return 0;
}
```

(a) (i) 5 4 3 2 1 (b) (i) 5 4 3 2 1
(ii) 5 5 4 3 2 (ii) infinite loop
(c) (i) 1 2 3 4 5 (d) None of these
(ii) No output

76. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
        int a,b;

        /* (a) */
        while(-1)
        {
                printf("Test Loop\n");
        }

        /* (b) */
        while(!0)
        {
                printf("Test Loop\n");
        }

        /* (c) */
        while(0)
        {
                printf("Test Loop\n");
        }
        /* (d) */
        a=0;
        while(a=0)
        {
                printf("Test Loop\n");
        }

        /* (e) */
        a=0;
        while(a=2)
        {
                printf("Test Loop\n");
        }
        /* (f) */
        a=0,b=1;
        while(a=b)
        {
                printf("Test Loop\n");
        }
        /* (g) */
        a=1,b=0;
        while(a=b)
        {
                printf("Test Loop\n");
        }
        return 0;
}
```


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77. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int i,j;

  /*(i)*/
  for(i=0; i<10; i++)
  printf("%d ",i);

  /*(ii)*/
  for(i=1; i<=10; i++)
  printf("%d ",i);

  /*(iii)*/
  for(i=0; i<=10; i++)
  printf("%d ",i);

  /*(iv)*/
  for(i=1; i<10; i++)
  printf("%d ",i);

  /*(v)*/
  for(i=0; i<=10; i--)
  printf("%d ",i);

  /*(vi)*/
  for(i=10; i>=1; i--)
  printf("%d ",i);

  /*(vii)*/
  for(i=10; i>1; i--)
  printf("%d ",i);

  /*(viii)*/
  for(i=10; i>0; i--)
  printf("%d ",i);

  /*(ix)*/
  for(i=15; i>=0; i=i - 3)
  printf("%d ",i);

  /*(x)*/
  for(i=10; i>=0; i--);
  printf("%d ",i);

  /*(xi)*/
  for(i=0; i>10; i++)
  printf("%d ",i);

  /*(xii)*/
  for(i=0; i<=10; i+=20)
  printf("%d ",i);

  /*(xiii)*/
  for(i=1;  i!=10;  i=i+2)
  printf("%d ",i);

  /*(xiv)*/
  for(j=10; i=j; j- =2)
  printf("%d ",i);

  /*(xv)*/
  for(i=10; i--; )
  printf("%d ",i);
  return 0;
}
```


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78. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int i;
  for(i=1; i<5; i++);
  printf("%d ",i);
  /*
  i=10;
  while(i<5);
  printf("%d ",i++);
  */
  /*
  i=0;
  while(i<5);
  printf("%d",i++);
  */
  return 0;
}
```

(a) 5 (b) 6 (c) 9 (d)10

79. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int i=1;
  while(i++ < 5)
  printf("%d ",i);
  printf("\n");
  i=1;
  while(++i < 5)
  printf("%d ",i);
  printf("\n");
  i=6;
  while(i--)
  printf("%d ",i);
  return 0;
}
```

80. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
  int a=6,b=4;
  while(a+b)
  {
      printf("a=%d, b=%d\n", a, b);
      a/=2;
      b%=3;
  }
  return 0;
}
```

(a) a = 9, b = 4 (b) a = 1, b = 1
(c) a = 0, b = 1 (d) Infinite loop

81. What is the output of the following program?

```
#include<stdio.h>
int main(void)
{
        int i=10;
        do
        {
                printf("i=%d\t", i);
                i=i-3;
        }while(i);
        return 0;
}
```

(a) 10
(b) 7
(c) infinite loop
(d) Compile time error

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82. What does the following fragment of C-program print?

```
char c[ ] = "GATE 2015";
char *P = C;
printf ("%c", *(P+P[3] – P[1] ));
```

(a) GATE 2015 (b) E2015
(c) 2 (d) 2015

83.
```
int f(int *P,int n)
{
        if(n<=0)
            return 0;
        else
        {
            if (*P% 2 = = 0)
                return *P + f(P + 1, n–1);
            else
                return *P – f(P + 1, n – 1);
        }
}
void main ( )
{
    int a[6] = {12,7,6,3,2,1};
    printf("%d", f(a,6) );
}
```

The output of the above program is_____.

84.
```
#include <stdio.h>
int f(int n, int k)
{
  if(n = = 0)
      return 0;
  else if (n % 2==1)
      return f(n/2, 2 * k) + k;
  else
      return f(n/2, 2 * k) – k;
}
int main ( )
{
  printf ("%d", f(10, 1));
}
```

The output of the above program is _____

85. What is the output of the following program?

```
#include<stdio.h>
int main( )
{
  int a=7;
  do
  {
        printf("a=%d\t", a);
        a=a – 3;
  }while(a);
  return 0;
}
```

(a) 4
(b) 7
(c) infinite loop
(d) Compile time error

86. What is the output of the following C code?

```
#include < stdio.h>
#include < conio.h>
void main ( )
{
  int index;
  for (index=1; index<=5; index++)
  {
        printf ("%d", index);
        if (index = = 3)
        continue;
  }
}
```

(a) 1245 (b) 12345
(c) 12245 (d) 12354

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87. Consider the following C function.

```
int fun(int n)
{
  int x = 1, k;
  if (n = = 1) return x;
  for (k =1; k<n; ++k)
  x = x + fun(k) * fun(n–k);
  return x;
}
```

The return value of fun(6) is _____.

88.

```
int sqr (int x);
int  cube (int x);
int func (int n);
int main ( )
{
  int n=8;
  printf ("%d\n",func (n));
  return 0;
}
int sqr (int x)
{ return x*x;  }
int cube (int x)
{  return x*x*x;  }
int func (int n)
{
  return n+sqr (n–2)+ cube (n–3);
}
```

The output of the above program is ____.

89.

```
void main ( )
{
  int a, b;
  int *ptr = (int*)0;
  if (ptr == (int *)0)
  {
        ptr = & a;
        a = 10;
        printf("\n value of a: % d", *ptr);
        ptr = (int*)0;
  }
  if(ptr ==(int *)0)
  {
        ptr = & b;
        b = 20;
        printf ("\n value of b: %d", *ptr);
  }
}
```

(a) 10 20 (b) 20 10
(c) 11 20 (d) None of these

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Solutions

01. Ans: (b)

Sol: Printf function returns the number of characters within double Quotes. First inside printf function prints Hi! then returns 3 and second printf function prints Bye then returns 3 The main printf prints the result of $3*3 = 9$.

02. Ans: (d)

Sol: In C Language anything within /* */ compiler considered as comment.

03. Ans: (b)

Sol: Within if statement printf function prints test then returns the number of characters as 4. Therefore the condition is true, control transfers to next statement below if. Printf function prints 'Success'.

04. Ans: (a)

Sol: printf(" % 10d", val)

It Prints 5 after 10 blank spaces

printf("% *d", val, val)

printf function replaces * by the value of val.

∴ It prints 5 after five blank spaces.

05. Ans: (c)

Sol: String: acbc

head(acbc) = a

tail(acbc) = cbc

tail(tail(acbc)) = tail(cbc) = bc

head(tail(tail(acbc))) = head(bc) = b

concat(head(acbc), head(tail(tail(acbc)))) = ab

06. Ans: (c)

Sol: one can pass structure variables by call by value and call by address.

07. Ans: (b)

Sol: Sizeof returns the sizeof the variable in bytes.

08. Ans: (c)

Sol: *X[3]→ Array of 3 pointers

*(*X[3])()→ Array of 3 pointers to function returning pointer.

09. Ans: (c)

Sol: **P:** Printf( ); produces compile Time Error

Q: Printf (NULL) ; Nothing to print

R: Printf("%d", printf(" ") + printf(" "));

Printf(" ") returns to zero because number of characters within double Quote is 0

10. Ans: (a)

Sol: x = 10

p(10) ⇒ p(a) ⇒ a = 10

a ≤ 40

a = a +10 = 20

p(20)

a ≤ 40

a = a + 10 = 30

p(30)

a ≤ 30

a = a + 10 = 40

p(40)

a = a + 10 = 50

p(50)

a ≤ 40 fails

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Retrieve a = 40
x = a+10 = 50
Retrieve next one
a = 30
x = a + 10 = 40
Retrieve next one a = 20
x = a+ 10 = 30

11. Ans: (c)

Sol: Since it is call by reference

p(50) (a = 50)

a ≮ 40

p(50) →	a = 50
p(40) →	a = 40
p(30) →	a = 30
p(20) →	a = 20

1st retrieval from stack
x = 50 + 10 = 60
2nd retrieval
x = 60 + 10 = 70
3rd retrieval
x = 70 + 10 = 80
4th retrieval
x = 80 + 10 = 90

12. Ans: (a)

Sol: Compiler replaces the macro values at the time of compilation

13. Ans: (c)

Sol: Definition of abstract data type

14. Ans: (d)

Sol: main ( ) declarations.

15. Ans: (b)

Sol: After function return the local variables are no more exist.

16. Ans: (d)

Sol: Go through the details of *l*–values and r– values.

17. Ans: (d)

Sol: C – imperative
Java- objective oriented
Lisp – functional
Prolog – constraint based

18. Ans: (c)

Sol: The order may vary from compiler to compiler.

19. Ans: (c)

Sol: Call by reference accepts address of the variable, actual argument must be variable.

20. Ans: (b)

Sol: Definition of life time

21. Ans: (a)

Sol: dangling reference definition

22. Ans: (c)

Sol: you cannot assign the address of one array to another array and the address of a variable to an array.

23. Ans: (a)

24. Ans: (a)

25. Ans: (a)

Sol: Call by value, no change in original variables

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26. Ans: (a)

Sol: Call by reference

27. Ans: (c)

Sol: char*(*P)( ) → P is a function pointer returning pointer to a character.

28. Ans: (a)

Sol: int c [ ] = {2,8,3,4,4,6,7,5}

*p=c, *q=c

	0	1	2	3	4	5	6	7
c	2	8	3	4	4	6	7	5
	2000	2002						

*p [2000] (3000) q [2000] (4000)

For j = 0 to 4
printf (*c)
++q
} prints 2,2,2,2,2

for j = 0 to 4
printf (*p)
++p
} prints 2,3,4,6,5

29. Ans: (a)

Sol: x and name are member variables

Struct KRK *p → pointer to structure variable

p → x prints x value

p → name prints string name

30. Ans: (b)

Sol: Call by reference

P(x) ⇒ Q(x) ⇒ 14

⇒ 14

Q(x) ⇒ 10

Print (x) = 10

31. Ans: (b)

Sol: P(x) ⇒ P(5)

⇒ x = 7

⇒ Q(7) ⇒ z = 7 + 7 = 14

Print (x) = 7

Q(5) ⇒ z = 5 + 5 = 10

Print (x) = 5

32. Ans: (a)

Sol: Object oriented paradigm supports

- Encapsulation
- Inheritance
- Polymorphism

33. Ans: (c)

Sol: x = 1

i = 1

→ 1 ≤ 1000

x = 2

i = 2

→ 2 ≤ 1000

$x = 2^2 = 4$

i = 3

→ 4 ≤ 1000

$x = 2^4 = 16$

i = 4

→ 16 ≤ 1000

$x = 2^{16} = 65536$

i = 5

34. Ans: (a)

Sol: I → True

II → C supports dynamic scope but C++ does not support.

III → May not be (false)

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35. Ans: (b)

Sol: Go through garbage collectors

36. Ans: (a)

Sol: P_1 calls P_3 and i = 7

P_3 calls P_2 and i = 5

P_2 prints i value as 7 because i = 5 is local to P_3

There P_2 can not access i = 5

37. Ans: (b)

Sol: P_1 calls P_3 and i = 7

P_3 calls P_2 and i = 5

P_2 prints i value as 5 because i = 5 is dynamic and is visible to P_2 function.

38. Ans: (a)

Sol: C++ does not support call by text.

39. Ans: (a)

Sol: Sub1 call prints 10

Sub2 call again calls Sub1 it prints 5.

40. Ans: (b)

Sol: a → False

b → True

c → False

d → False

41. Ans: (a)

Sol: Pointers uses indirect address mode.

42. Ans: (d)

Sol: call by reference and dynamic scoping.

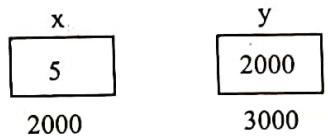
z holds 2

∴ write (y) print 2

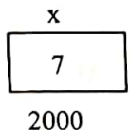
43. Ans: (d)

Sol: Initial call P(x) – call by reference

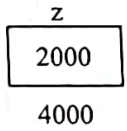
y holds address of x



From procedure P ⇒



Now it calls Q procedure



From z = z + x equation

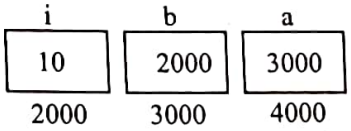
Print (z) Prints 14

Print (x) Prints 14

again Print (x) prints 14

44. Ans: (d)

Sol: t = f(i, b, a) = f (10, b, a)



x = 10, *y = b, **z = a

**z = **z + 2 = 12

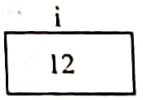
m = 12

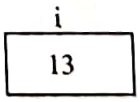
* y = * y + 1 = 13

k = 13

x = 10 + 5 = 15

return (15 + 13 + 12)





45. Ans: (c) **46. Ans: (b)**

47. Ans: (d) **48. Ans: (a)**

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49. Ans: (c)

50. Ans: (c)

51. Ans: (a)

Sol: The arguments to swap2 are passed by value

52. Ans: (c)

53. Ans: (a)

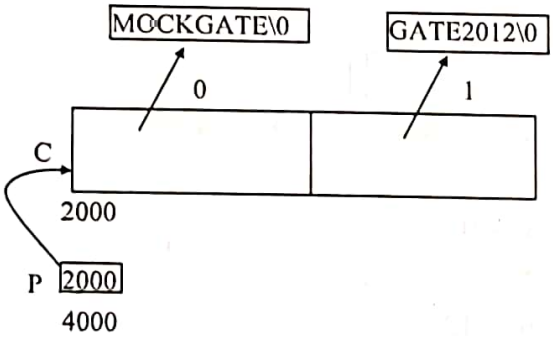
54. Ans: (d)

Sol: Apply dynamic scoping with call by reference mechanism

55. Ans: (d)

56. Ans: (d)

Sol:



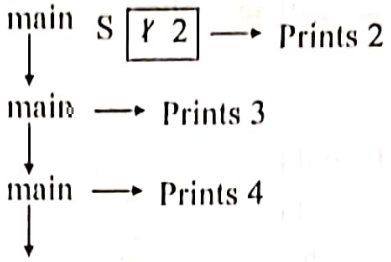
57. Ans: (a)

Sol: Parameters are evaluated from right to left so in abc(++a, a++); it is first a++ evaluated , later ++a evaluated

∴ abc(12,10); i.e. passing values 12,10 to abc(int x, int y).

58. Ans: (c)

Sol:



When condition fails, stack values are printed.

59. Ans: (a)

Sol:

Step 1:

main

i	j	k	m
1	2	3	

Step: 2 **Procedure P**

i	j	k
1	3	4

i = i + k; // i = 1 + 4;
j = j + k; // j = 3 + 4;

i	j
5	7

(i, j are updated in P)

Step: 3 **Procedure Q**

i	m
5	7

i = i + k; // i = 5 + 3;
m = j + 1; // m = 2 + 1;

i	m
8	3

(i, m are updated in Q)

Writeln(i, j, k, m); prints 8,2,3,3

60. Ans: (c)

Sol:

Step 1:

main

i	j	k	m
1	2	3	

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Step 2: **Procedure P**

i, j are alias to above i, k variables respectively

k

4

i = i + k; // i = 1 + 4;
j = j + k; // j = 3 + 4;
So main function variables i, k are updated to 5 and 7 respectively

Step 3: **Procedure Q**

i, j are alias to above i,k variables respectively

i = i + k; // i = 5 + 7;
m= j + 1; // m = 2 + 1;
So main function variables i,k are updated to 12 and 3 respectively
∴ writeln (i, j, k, m) prints the output 12,2,3,3

61. Ans: (d)

Sol: When we are working with global variable if the declaration statement not available, then we will get compile time error, if the definition is not available we get linking error.

62. Ans: (a)

Sol: char(*(*f())[ ])(); Function 'f' returns a pointer to an array of pointers to a function return a character

63. Ans: (a)

Sol: test_b(4)→First calls test_b(2)→prints 4
↑
next test_b(2) calls test_b (0) →it prints 2
↑
test_b(0) → since 0 > 0 fails it prints 0

64. Ans: (a)

Sol: It calculates X^n

65. Ans: (c)

Sol: A = Do(2, 18) return 2 * A * A

A = Do(2, 9) return A * A

A = Do(2, 4) return 2 * A * A

A = Do(2, 2) return A * A

A = Do(2, 1) return A * A

A = 2 ⇒ A = Do(2, 1) return $2 * 2 = 2^2$

⇒ A = Do(2, 2) return $2^2 * 2^2 = 2^4$

⇒ A = Do(2, 4) return $2 * 2^4 * 2^4 = 2^9$

⇒ A = Do(2, 9) return $2^9 * 2^9 = 2^{18}$

⇒ A = Do(2,18) return $2*2^{18}* 2^{18} = 2^{37}$

Number of multiplications = 7

66. Ans: (b)

Sol: The mistake here is that equality operator is used instead of assignment operator for assigning the value to i. So i is compared with 50 and the result of the expression is 0 which is discarded. The variable i remains unassigned.

67. Ans: (a)

Sol: Only the statement a = a–5 is part of the if statement, the statement b = b + 5 will always be executed. If we want the statement b = b + 5 to become part of if statement then we need to enclose both statement within braces.

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```
if (a < 10)
{
        a = a –5;
        b = b + 5;
}
```

68. Ans: (c)

Sol: There is a semicolon after the condition of if statement, and it is considered as a null statement.

```
if (i > = 5 && j < 5)
  ;
i = j + 2;
```

So the statement i = j + 2 will always be executed.

69. Ans: (b)

70. Ans: (b)

Sol: a is not 2.

Here the else part is paired with the second if, if we want to pair it with the first if then we should enclosed the second if inside braces.

```
if(a = = 2)
{
        if(x = = 8)
        printf("a is 2 and x is 8 \n");
}
else
        printf("a is not 2 \n");
```

71. Ans: (c)

Sol: Error, continue can't be used inside switch.

72. Ans: (d)

Sol: Error, case expressions are not constant expressions.

73. Ans: (a)

Sol: Here the continue statement is in a switch which is enclosed inside a for loop so the continue statement applies to the for loop.

74. Ans: (b)

Sol: Any executable statement inside a switch before the first case label is ignored by the compiler and is never executed.

75. Ans: (b)

Sol: (i) 5 4 3 2 1, (ii) This program runs infinitely, because the goto statement is not inside the if structure.

76.

Sol: (a) –1 is a non zero value so the loop condition is always true, hence the loop will iterate infinitely.

(b) Loop will iterate infinitely.

(c) Loop condition is false, so the loop will not iterate even once.

(d) Variable a is assigned value zero in loop condition a = 0, the value of this expression is 0 so the condition is false, and the loop will not iterate even once.

(e) Variable a is assigned value 2 in loop condition a = 2, the value of this expression is 2 so the second condition is true, and the loop will iterate infinitely.

(f) Variable a is assigned value of b which is 1 and so the value of expression a = b is 1, thus the loop will iterate infinitely.

(g) Variable a is assigned value of b which is 0, and so the value of expression a = b is 0, thus the loop will not iterate even once.

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77.

Sol: (i) 0 1 2 3 4 5 6 7 8 9

(ii) 1 2 3 4 5 6 7 8 9 10

(iii) 0 1 2 3 4 5 6 7 8 9 10

(iv) 1 2 3 4 5 6 7 8 9

(v) This loop will run infinitely, Value of i is initially 0 and it is decremented in each loop iteration, so i will never exceed 10 and hence the condition i <= 10 never becomes false.

(vi) 10 9 8 7 6 5 4 3 2 1

(vii) 10 9 8 7 6 5 4 3 2

(viii) 10 9 8 7 6 5 4 3 2 1

(ix) 15 12 9 6 3 0

(x) –1

There is a semicolon after the closing parenthesis of for statement, this acts as a null statement.

for(i = 10; i >= 0; i – –);

printf("%d", i);

The loop iterates 11 times and when the value of i becomes –1, control comes out of the loop and value of i is printed.

(xi) Loop condition is initially false so the loop does not iterate even once.

(xii) 0 This loop will iterate once and after that the condition will becomes false.

(xiii) 1 3 5 7 9 11 13 15 .....

This loop will iterate infinitely as the value of i will never become 10.

(xiv) 10 8 6 4 2

The loop terminates when the value of assignment expression (i = j) becomes zero.

(xv) 9 8 7 6 5 4 3 2 1 0

The loop terminates when the value of expression i – – becomes zero.

78. Ans: (a)

Sol: In all the three loops, the loop body is a single null statement(;), The first loop will iterate 4 times and will terminate when the value of i becomes 5. So the first printf prints 5. In the second loop, the loop condition is false so it will no iterate and the printf will print 10. In the third loop, the loop condition is true so it will iterate infinitely and the printf will not be executed.

79.

Sol: 2 3 4 5

2 3 4

5 4 3 2 1 0

80. Ans: (d)

Sol: a = 6, b = 4

a = 3, b = 1

a = 1, b = 0

a = 0, b = 1

a = 0, b = 1

a = 0, b = 1

.....

The value of b never becomes zero, and so the condition never becomes false resulting in an infinite loop.

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81. Ans: (c)

Sol: 10 7 4 1 –2 –5 –8.....

The value of i never becomes zero, resulting in an infinite loop.

82: Ans(c)

83. Ans: 13

84. Ans: 5

Sol: f(10, 1)

n = 10, k =1

⇒ f(5, 2) – 1

n = 5, k =2

⇒ f(2,4) + 2 –1 = f(2,4)+1

n = 2, k =4

⇒ f(1,8) – 4+1 = f(1, 8) – 3

n = 1, k =8

⇒ f(0, 16) + 8 – 3 = f(0, 16) + 5

⇒ 0 +8 – 3 = 5

f(10, 1) = 5

85. Ans: (c)

Sol: 7 4 1 –2 –5 –8.....

The value of a never becomes zero, resulting in an infinite loop.

86. Ans: (b)

87. Ans: 188

Sol: $x = x + \sum_{k=1}^{5} f(k) \times f(6-k)$

f(1) = 1, f(2) = 2, f(3)=5, f(4) = 15, f(5) = 51

∴ x = x+ [f(1) * f(5) +f(2)*f(4) +f(3)*f(3) + f(4) *f(2) + f(5) * f(1)]

∴ x = 188

88. Ans: 169

89. Ans: (a)

Sol: value of a: 10

value of b: 20

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