STD. XII Sci.
Triumph Maths
Based on Maharashtra Board Syllabus

Salient Features

- Exhaustive subtopic wise coverage of MCQs.
- Important formulae provided in each chapter.
- Hints included for relevant questions.
- Various competitive exam questions updated till the latest year.
- Includes solved MCQs from JEE (Main) 2014, 15, 16, MHT CET 2016.
- Evaluation test provided at the end of each chapter.
- Includes Two Model Question Papers and MHT CET 2016 Question paper.

Solutions/hints to Evaluation Test available in downloadable PDF format at www.targetpublications.org/tp10090

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P.O. No. 26980
**Preface**

“Std. XII: Sci. Triumph Maths” is a complete and thorough guide to prepare students for a competitive level examination. The book will not only assist students with MCQs of Std. XII, but will also help them to prepare for JEE (Main), CET and various other competitive examinations.

The content of this book is based on the Maharashtra State Board Syllabus. Formulae that form a key part for solving MCQs have been provided in each chapter. Shortcuts provide easy and less tedious solving methods.

MCQs in each chapter are divided into three sections:

- **Classical Thinking**: consists of straight forward questions including knowledge based questions.
- **Critical Thinking**: consists of questions that require some understanding of the concept.
- **Competitive Thinking**: consists of questions from various competitive examinations like JEE (Main), CET, etc.

Hints have been provided to the MCQs which are broken down to the simplest form possible.

An Evaluation Test has been provided at the end of each chapter to assess the level of preparation of the student on a competitive level.

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we’ve nearly missed something or want to applaud us for our triumphs, we’d love to hear from you.

Please write to us on: mail@targetpublications.org

Best of luck to all the aspirants!

Yours faithfully

Authors

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Chapter 01: Mathematical Logic

Subtopics

1.1 Statement, Logical Connectives, Compound Statements and Truth Table
1.2 Statement Pattern, Logical Equivalence, and Algebra of Statements
1.3 Tautology, Contradiction, Contingency
1.4 Quantifiers and Quantified Statements, Duality
1.5 Negation of compound statements
1.6 Switching circuit

Aristotle (384 - 322 B.C.)

Aristotle the great philosopher and thinker laid the foundations of study of logic in systematic form. The study of logic helps in increasing one’s ability of systematic and logical reasoning and develops the skill of understanding validity of statements.
1. **Statement**
   A statement is declarative sentence which is either true or false, but not both simultaneously.
   - Statements are denoted by lower case letters p, q, r, etc.
   - The truth value of a statement is denoted by ‘1’ or ‘T’ for True and ‘0’ or ‘F’ for False.

   Open sentences, imperative sentences, exclamatory sentences and interrogative sentences are not considered as Statements in Logic.

2. **Logical connectives**

<table>
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<th>Connective</th>
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<td>↔ or ⇔</td>
<td>p iff q : p ↔ q</td>
</tr>
</tbody>
</table>

   i. When two or more simple statements are combined using logical connectives, then the statement so formed is called Compound Statement.
   ii. Sub-statements are those simple statements which are used in a compound statement.
   iii. In the conditional statement p → q, p is called the antecedent or hypothesis, while q is called the consequent or conclusion.

3. **Truth Tables for compound statements:**
   i. Conjunction, Disjunction, Conditional and Biconditional:

      | p | q | p ∧ q | p ∨ q | p → q | p ↔ q |
      |---|---|-------|-------|-------|-------|
      | T | T | T     | T     | T     | T     |
      | T | F | F     | T     | F     | F     |
      | F | T | F     | T     | T     | F     |
      | F | F | F     | T     | T     | T     |

   ii. Negation:

      | p | ~ p |
      |---|----|
      | T | F  |
      | F | T  |

4. **Relation between compound statements and sets in set theory:**
   i. Negation corresponds to ‘complement of a set’.
   ii. Disjunction is related to the concept of ‘union of two sets’.
   iii. Conjunction corresponds to ‘intersection of two sets’.
   iv. Conditional implies ‘subset of a set’.
   v. Biconditional corresponds to ‘equality of two sets’.

5. **Statement Pattern:**
   When two or more simple statements p, q, r ... are combined using connectives ∧, ∨, ~, →, ↔ the new statement formed is called a statement pattern.

   e.g.: ~ p ∧ q, p ∧ (p ∧ q), (q → p) ∨ r

6. **Converse, Inverse, Contrapositive of a Statement:**
   If p → q is a conditional statement, then its
   i. Converse: q → p
   ii. Inverse: ~p → ~q
   iii. Contrapositive: ~q → ~p
7. **Logical equivalence:**

If two statement patterns have the same truth values in their respective columns of their joint truth table, then these two statement patterns are **logically equivalent.**

Consider the truth table:

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>~p</th>
<th>~q</th>
<th>p → q</th>
<th>q → p</th>
<th>~p → ~q</th>
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From the given truth table, we can summarize the following:

i. The given statement and its contrapositive are logically equivalent.

i.e. \( p \rightarrow q \equiv \sim q \rightarrow \sim p \)

ii. The converse and inverse of the given statement are logically equivalent.

i.e. \( q \rightarrow p \equiv \sim p \rightarrow \sim q \)

8. **Algebra of statements:**

i. \( p \lor q \equiv q \lor p \)

\( p \land q \equiv q \land p \)

\( p \lor q \land r \equiv (p \lor q) \land (p \lor r) \)

\( p \land (q \lor r) \equiv (p \land q) \lor (p \land r) \)

\( \sim (p \lor q) \equiv \sim p \land \sim q \)

\( \sim (p \land q) \equiv \sim p \lor \sim q \)

\( p \rightarrow q \equiv \sim p \lor q \)

\( p \leftrightarrow q \equiv (p \rightarrow q) \land (q \rightarrow p) \)

iv. \( \sim (p \lor q) \equiv \sim p \land \sim q \)

\( \sim (p \land q) \equiv \sim p \lor \sim q \)

\( \sim (\sim p) \equiv p \)

\( \sim \sim p \equiv p \)

\( (p \lor q) \land (p \land q) \equiv p \)

\( (p \lor q) \land (p \land q) \equiv p \)

\( p \lor \sim p \equiv T \)

\( p \land \sim p \equiv F \)

\( p \lor (p \land q) \equiv p \)

\( p \land (p \lor q) \equiv p \)

\( p \lor \sim p \equiv T \)

\( p \land \sim p \equiv F \)

\( \sim (\sim p) \equiv p \)

\( \sim T \equiv F \)

\( \sim F \equiv T \)

\( p \lor p \equiv p \)

\( p \land p \equiv p \)

\( \sim (\sim p) \equiv p \)

\( \sim T \equiv F \)

\( \sim F \equiv T \)

\( p \lor p \equiv p \)

\( p \land p \equiv p \)

\( \sim T \equiv F \)

\( \sim F \equiv T \)

\( p \lor p \equiv p \)

\( p \land p \equiv p \)

\( \sim T \equiv F \)

\( \sim F \equiv T \)

\( p \lor p \equiv p \)

\( p \land p \equiv p \)
9. Types of Statements:
   i. If a statement is **always true**, then the statement is called a “tautology”.
   ii. If a statement is **always false**, then the statement is called a “contradiction” or a “fallacy”.
   iii. If a statement is **neither a tautology nor a contradiction**, then it is called “contingency”.

10. Quantifiers and Quantified Statements:
    i. The symbol ‘∀’ stands for “all values of” or “for every” and is known as **universal quantifier**.
    ii. The symbol ‘∃’ stands for “there exists at least one” and is known as **existential quantifier**.
    iii. When a quantifier is used in an open sentence, it becomes a statement and is called a **quantified statement**.

11. Principles of Duality:
    Two compound statements are said to be dual of each other, if one can be obtained from the other by replacing “∧” by “∨” and vice versa. The connectives “∧” and “∨” are duals of each other. If ‘t’ is tautology and ‘c’ is contradiction, then the special statements ‘t’ & ‘c’ are duals of each other.

12. Negation of a Statement:
    i. \( \sim (p \lor q) \equiv \sim p \land \sim q \)
    ii. \( \sim (p \land q) \equiv \sim p \lor \sim q \)
    iii. \( \sim (p \to q) \equiv p \land \sim q \)
    iv. \( \sim (p \leftrightarrow q) \equiv (p \land \sim q) \lor (q \land \sim p) \)
    v. \( \sim (\forall x) \equiv \exists x \)
    vi. \( \sim (\exists x) \equiv \forall x \)
    vii. \( \sim (x < y) \equiv x \geq y \)
    viii. \( \sim (x > y) \equiv x \leq y \)

13. Application of Logic to Switching Circuits:
    i. **AND** : \( [\land] \) (Switches in series)
       Let \( p : S_1 \) switch is ON
          \( q : S_2 \) switch is ON
       For the lamp L to be ‘ON’ both \( S_1 \) and \( S_2 \) must be ON
       Using theory of logic, the adjacent circuit can be expressed as, \( p \land q \).

    ii. **OR** : \( [\lor] \) (Switches in parallel)
       Let \( p : S_1 \) switch is ON
          \( q : S_2 \) switch is ON
       For lamp L to be put ON either one of the two switches \( S_1 \) and \( S_2 \) must be ON.
       Using theory of logic, the adjacent circuit can be expressed as \( p \lor q \).

    iii. If two or more switches open or close simultaneously then the switches are denoted by the same letter.
       If \( p \) : switch S is closed.
          \( \sim p \) : switch S is open.
       If \( S_1 \) and \( S_2 \) are two switches such that if \( S_1 \) is open \( S_2 \) is closed and vice versa.
       then \( S_1 \equiv \sim S_2 \)
       or \( S_2 \equiv \sim S_1 \)
1.1 Statement, Logical Connectives, Compound Statements and Truth Table

1. Which of the following is a statement in logic?
   (A) What a wonderful day!
   (B) Shut up!
   (C) What are you doing?
   (D) Bombay is the capital of India.

2. Which of the following is a statement?
   (A) Open the door.
   (B) Do your homework.
   (C) Switch on the fan.
   (D) Two plus two is four.

3. Which of the following is a statement in logic?
   (A) Go away (B) How beautiful!
   (C) x > 5 (D) 2 = 3

4. The connective in the statement “Earth revolves around the Sun and Moon is a satellite of earth”, is
   (A) or (B) Earth
   (C) Sun (D) and

5. p: Sunday is a holiday, q: Ram does not study on holiday.
   The symbolic form of the statement ‘Sunday is a holiday and Ram studies on holiday’ is
   (A) p ∧ ~q (B) p ∧ q
   (C) ~p ∧ ~q (D) p ∨ q

6. p: There are clouds in the sky and q: it is not raining. The symbolic form is
   (A) p → q (B) p → ~q
   (C) ~p ∧ q (D) ~p ∨ q

7. If p: The sun has set, q: The moon has risen, then symbolically the statement ‘The sun has not set or the moon has not risen’ is written as
   (A) p ∧ ~q (B) ~q ∨ p
   (C) ~p ∧ q (D) ~p ∨ ~q

8. If p: Rohit is tall, q: Rohit is handsome, then the statement ‘Rohit is tall or he is short and handsome’ can be written symbolically as
   (A) p ∨ (~p ∧ q)
   (B) p ∧ (~p ∨ q)
   (C) p ∨ (p ∧ ~q)
   (D) ~p ∧ (~p ∧ ~q)

9. Assuming the first part of the statement as p, second as q and the third as r, the statement ‘Candidates are present, and voters are ready to vote but no ballot papers’ in symbolic form is
   (A) (p ∨ q) ∧ ~r
   (B) (p ∧ ~q) ∧ r
   (C) (~p ∧ q) ∧ ~r
   (D) (p ∧ q) ∧ ~r

10. Write verbally ~p ∨ q where p: She is beautiful; q: She is clever
    (A) She is beautiful but not clever
    (B) She is not beautiful or she is clever
    (C) She is not beautiful or she is not clever
    (D) She is beautiful and clever.

11. If p: Ram is lazy, q: Ram fails in the examination, then the verbal form of ~p ∨ ~q is
    (A) Ram is not lazy and he fails in the examination.
    (B) Ram is not lazy or he does not fail in the examination.
    (C) Ram is lazy or he does not fail in the examination.
    (D) Ram is not lazy and he does not fail in the examination.

12. A compound statement p or q is false only when
    (A) p is false.
    (B) q is false.
    (C) both p and q are false.
    (D) depends on p and q.

13. A compound statement p and q is true only when
    (A) p is true.
    (B) q is true.
    (C) both p and q are true.
    (D) none of p and q is true.

14. For the statements p and q ‘p → q’ is read as ‘if p then q’. Here, the statement q is called
    (A) antecedent.
    (B) consequent.
    (C) logical connective.
    (D) prime component.

15. If p: Prakash passes the exam, q: Papa will give him a bicycle.
    Then the statement ‘Prakash passing the exam, implies that his papa will give him a bicycle’ can be symbolically written as
    (A) p → q
    (B) p ↔ q
    (C) p ∧ q
    (D) p ∨ q
16. If d: driver is drunk, a: driver meets with an accident, translate the statement ‘If the Driver is not drunk, then he cannot meet with an accident’ into symbols

(A) \( \neg a \rightarrow \neg d \)  
(B) \( \neg d \rightarrow \neg a \)  
(C) \( \neg d \land a \)  
(D) \( a \land \neg d \)

17. If a: Vijay becomes a doctor, b: Ajay is an engineer.

Then the statement ‘Vijay becomes a doctor if and only if Ajay is an engineer’ can be written in symbolic form as

(A) \( b \leftrightarrow \neg a \)  
(B) \( a \leftrightarrow b \)  
(C) \( a \rightarrow b \)  
(D) \( b \rightarrow a \)

18. A compound statement \( p \rightarrow q \) is false only when

(A) \( p \) is true and \( q \) is false.  
(B) \( p \) is false but \( q \) is true.  
(C) at least one of \( p \) or \( q \) is false.  
(D) both \( p \) and \( q \) are false.

19. Assuming the first part of each statement as \( p \), second as \( q \) and the third as \( r \), the statement ‘If A, B, C are three distinct points, then either they are collinear or they form a triangle’ in symbolic form is

(A) \( p \leftrightarrow (q \lor r) \)  
(B) \( (p \land q) \rightarrow r \)  
(C) \( p \rightarrow (q \lor r) \)  
(D) \( p \rightarrow (q \land r) \)

20. If m: Rimi likes calculus.

n: Rimi opts for engineering branch.

Then the verbal form of \( m \rightarrow n \) is

(A) If Rimi opts for engineering branch then she likes calculus.  
(B) If Rimi likes calculus then she does not opt for engineering branch.  
(C) If Rimi likes calculus then she opts for engineering branch.  
(D) If Rimi likes engineering branch then she opts for calculus.

21. The inverse of logical statement \( p \rightarrow q \) is

(A) \( \neg p \rightarrow \neg q \)  
(B) \( p \leftrightarrow q \)  
(C) \( q \rightarrow p \)  
(D) \( q \leftrightarrow p \)

22. Contrapositive of \( p \rightarrow q \) is

(A) \( q \rightarrow p \)  
(B) \( \neg q \rightarrow \neg p \)  
(C) \( \neg q \rightarrow \neg p \)  
(D) \( q \rightarrow \neg p \)

23. The statement ‘If \( x^2 \) is not even then \( x \) is not even’, is the converse of the statement

(A) If \( x^2 \) is odd, then \( x \) is even  
(B) If \( x \) is not even, then \( x^2 \) is not even  
(C) If \( x \) is even, then \( x^2 \) is even  
(D) If \( x \) is odd, then \( x^2 \) is even

24. The converse of ‘If \( x \) is zero then we cannot divide by \( x \)’ is

(A) If we cannot divide by \( x \) then \( x \) is zero.  
(B) If we divide by \( x \) then \( x \) is non-zero.  
(C) If \( x \) is non-zero then we can divide by \( x \).  
(D) If we cannot divide by \( x \) then \( x \) is non-zero.

25. The converse of the statement ‘If \( x > y \), then \( x + a > y + a \)’, is

(A) If \( x < y \), then \( x + a < y + a \)  
(B) If \( x + a > y + a \), then \( x > y \)  
(C) If \( x < y \), then \( x + a > y + a \)  
(D) If \( x > y \), then \( x + a < y + a \)

26. The inverse of the statement ‘If you access the internet, then you have to pay the charges’, is

(A) If you do not access the internet, then you do not have to pay the charges.  
(B) If you pay the charges, then you accessed the internet.  
(C) If you do not pay the charges, then you do not access the internet.  
(D) You have to pay the charges if and only if you access the internet.

27. The contrapositive of the statement: ‘If a child concentrates then he learns’ is

(A) If a child does not concentrate he does not learn.  
(B) If a child does not learn then he does not concentrate.  
(C) If a child practises then he learns.  
(D) If a child concentrates, he does not forget.
28. If p: Sita gets promotion, q: Sita is transferred to Pune. The verbal form of \( \sim p \leftrightarrow q \) is written as
(A) Sita gets promotion and Sita gets transferred to Pune.
(B) Sita does not get promotion then Sita will be transferred to Pune.
(C) Sita gets promotion if Sita is transferred to Pune.
(D) Sita does not get promotion if and only if Sita is transferred to Pune.

29. Negation of a statement in logic corresponds to _______ in set theory.
(A) empty set
(B) null set
(C) complement of a set
(D) universal set

30. The logical statement ‘p \& q’ can be related to the set theory’s concept of
(A) union of two sets
(B) intersection of two sets
(C) subset of a set
(D) equality of two sets

31. If p and q are two logical statements and A and B are two sets, then p \( \rightarrow \) q corresponds to
(A) A \( \subseteq \) B
(B) A \( \cap \) B
(C) A \( \cup \) B
(D) A \( \not\subseteq \) B

32. Every conditional statement is equivalent to
(A) its contrapositive
(B) its inverse
(C) its converse
(D) only itself

33. The statement, ‘If it is raining then I will go to college’ is equivalent to
(A) If it is not raining then I will not go to college.
(B) If I do not go to college, then it is not raining.
(C) If I go to college then it is raining.
(D) Going to college depends on my mood.

34. The logically equivalent statement of (p \& q) \( \lor \) (p \& r) is
(A) p \( \lor \) (q \& r)  (B) q \( \lor \) (p \& r)
(C) p \& (q \& r)  (D) q \& (p \& r)

35. When the compound statement is true for all its components then the statement is called
(A) negation statement.
(B) tautology statement.
(C) contradiction statement.
(D) contingency statement.

36. The statement (p \& q) \( \rightarrow \) p is
(A) a contradiction  (B) a tautology
(C) either (A) or (B)  (D) a contingency

37. The proposition (p \& q) \& (p \( \rightarrow \) \sim q) is
(A) Contradiction
(B)  Tautology
(C)  Contingency
(D)  Tautology and Contradiction

38. The proposition p \( \rightarrow \) (~p \& ~q) is a
(A) contradiction  (B) tautology.
(C) contingency.  (D) none of these

39. The proposition (p \( \rightarrow \) q) \( \leftrightarrow \) (~p \& ~q) is a
(A) tautology
(B) contradiction
(C) contingency
(D) none of these

40. Using quantifiers \( \forall, \exists \), convert the following open statement into true statement.
‘\( x + 5 = 8, x \in N \)’
(A) \( \forall x \in N, x + 5 = 8 \)
(B) For every \( x \in N, x + 5 > 8 \)
(C) \( \exists x \in N, \text{ such that } x + 5 = 8 \)
(D) For every \( x \in N, x + 5 < 8 \)

41. Using quantifier the open sentence ‘\( x^2 - 4 = 32 \)’ defined on W is converted into true statement as
(A) \( \forall x \in W, x^2 - 4 = 32 \)
(B) \( \exists x \in W, \text{ such that } x^2 - 4 \leq 32 \)
(C) \( \forall x \in W, x^2 - 4 > 32 \)
(D) \( \exists x \in W, \text{ such that } x^2 - 4 = 32 \)

42. Dual of the statement (p \& q) \( \lor \) \sim q \equiv p \lor \sim q is
(A) (p \lor q) \sim q \equiv p \lor \sim q
(B) (p \& q) \sim q \equiv p \& \sim q
(C) (p \lor q) \sim q \equiv p \& \sim q
(D) (~p \lor \sim q) \& q \equiv \sim p \& q
43. The dual of the statement “Manoj has the job but he is not happy” is
   (A) Manoj has the job or he is not happy.
   (B) Manoj has the job and he is not happy.
   (C) Manoj has the job and he is happy.
   (D) Manoj does not have the job and he is happy.

1.5 Negation of compound statements

44. Which of the following is logically equivalent to \( \neg(p \land q) \)?
   (A) \( p \land q \)
   (B) \( \neg p \lor \neg q \)
   (C) \( \neg(p \lor q) \)
   (D) \( \neg p \land \neg q \)

45. \( \neg(p \lor \neg q) \) is equal to
   (A) \( \neg p \lor q \)
   (B) \( \neg p \land q \)
   (C) \( \neg (p \lor q) \)
   (D) \( \neg p \land \neg q \)

46. The negation of the statement “I like Mathematics and English” is
   (A) I do not like Mathematics and do not like English
   (B) I like Mathematics but do not like English
   (C) I do not like Mathematics but like English
   (D) Either I do not like Mathematics or do not like English

47. \( \neg(p \leftrightarrow q) \) is equivalent to
   (A) \( (p \land \neg q) \lor (q \land \neg p) \)
   (B) \( (p \lor \neg q) \land (q \lor \neg p) \)
   (C) \( (p \rightarrow q) \land (q \rightarrow p) \)
   (D) \( (q \rightarrow p) \lor (p \rightarrow q) \)

48. The negation of ‘If it is Sunday then it is a holiday’ is
   (A) It is a holiday but not a Sunday.
   (B) No Sunday then no holiday.
   (C) It is Sunday, but it is not a holiday.
   (D) No holiday therefore no Sunday.

49. The negation of ‘For every natural number \( x \), \( x + 5 > 4 \)’ is
   (A) \( \forall x \in \mathbb{N}, x + 5 < 4 \)
   (B) \( \forall x \in \mathbb{N}, x - 5 < 4 \)
   (C) For every integer \( x \), \( x + 5 < 4 \)
   (D) There exists a natural number \( x \), for which \( x + 5 \leq 4 \)

1.6 Switching circuit

50. The switching circuit for the statement \( p \land q \land r \) is
   (A) \[ \text{Diagram A} \]
   (B) \[ \text{Diagram B} \]
   (C) \[ \text{Diagram C} \]
   (D) \[ \text{Diagram D} \]

51. If the current flows through the given circuit, then it is expressed symbolically as,
   (A) \( (p \land q) \lor r \)
   (B) \( (p \land q) \lor \neg r \)
   (C) \( (p \lor q) \lor (\neg p \land r) \)
   (D) \( (p \lor q) \lor (\neg p \land \neg r) \)

52. The switching circuit in symbolic form of logic, is
   (A) \( p \land \neg q \)
   (B) \( p \lor \neg q \)
   (C) \( p \lor q \)
   (D) \( p \land \neg q \)

53. The switching circuit in symbolic form of logic, is
   (A) \( (p \land q) \lor (\neg p) \lor (p \land \neg q) \)
   (B) \( (p \lor q) \lor (\neg p) \lor (p \land \neg q) \)
   (C) \( (p \land q) \land (\neg p) \lor (p \land \neg q) \)
   (D) \( (p \lor q) \land (\neg p) \lor (p \land \neg q) \)
1.1 Statement, Logical Connectives, Compound Statements and Truth Table

1. Which of the following is an incorrect statement in logic?
   (A) Multiply the numbers 3 and 10.
   (B) 3 times 10 is equal to 40.
   (C) What is the product of 3 and 10?
   (D) 10 times 3 is equal to 30.

2. Assuming the first part of the sentence as p and the second as q, write the following statement symbolically:
   ‘Irrespective of one being lucky or not, one should not stop working’
   (A) (p ∧ ~p) ∨ q
   (B) (p ∨ ~p) ∧ q
   (C) (p ∨ ~p) ∧ ~q
   (D) (p ∧ ~p) ∨ ~q

3. If first part of the sentence is p and the second is q, then the symbolic form of the statement
   ‘It is not true that Physics is not interesting or difficult’ is
   (A) ~(~p ∧ q) (B) (~p ∨ q)
   (C) (~p ∨ ~q) (D) ~(~p ∨ q)

4. The symbolic form of the statement ‘It is not true that intelligent persons are neither polite nor helpful’ is
   (A) ~p ∨ q
   (B) ~(p ∨ ~p) ∧ q
   (C) ~(p ∨ ~p) ∧ ~q
   (D) (p ∧ ~p) ∨ ~q

5. Given ‘p’ and ‘q’ as true and ‘r’ as false, the truth values of ~(p ∧ (q ∨ ~r)) and (p → q) ∧ r are respectively
   (A) T, F (B) F, F
   (C) T, T (D) F, T

6. If p and q have truth value ‘F’, then the truth values of (~p ∨ q) ↔ ~p and ~p ↔ (p → ~q) are respectively
   (A) T, T (B) F, F
   (C) T, F (D) F, T

7. If p is true and q is false then the truth values of (p → q) ↔ (~q → ~p) and (~p ∨ q) ∧ (~q ∨ p) are respectively
   (A) F, F (B) F, T
   (C) T, F (D) T, T

8. If p is false and q is true, then
   (A) p ∧ q is true
   (B) p ∨ ~q is true
   (C) q → p is true
   (D) p → q is true

1.2 Statement Pattern, Logical Equivalence, and Algebra of Statements

12. Find out which of the following statements have the same meaning:
   i. If Seema solves a problem then she is happy.
   ii. If Seema does not solve a problem then she is not happy.
   iii. If Seema is not happy then she hasn’t solved the problem.
   iv. If Seema is happy then she has solved the problem
   (A) (i, ii) and (iii, iv)
   (B) i, ii, iii
   (C) (i, iii) and (ii, iv)
   (D) ii, iii, iv

13. Find which of the following statements convey the same meanings?
   i. If it is the bride’s dress then it has to be red.
   ii. If it is not bride’s dress then it cannot be red.
   iii. If it is a red dress then it must be the bride’s dress.
   iv. If it is not a red dress then it can’t be the bride’s dress.
   (A) (i, iv) and (ii, iii)
   (B) (i, ii) and (iii, iv)
   (C) (i, iii) and (ii, iv)
   (D) (i, iii) and (ii, iv)

14. p ∧ (p → q) is logically equivalent to
   (A) p ∨ q
   (B) ~p ∨ q
   (C) p ∧ q
   (D) p ∨ ~q
15. \( \sim (p \lor q) \lor (\sim p \land q) \) is logically equivalent to
   (A) \( \sim p \)
   (B) \( p \)
   (C) \( q \)
   (D) \( \sim q \)

16. Which of the following is true?
   (A) \( p \land \sim p \equiv T \)
   (B) \( p \lor \sim p \equiv F \)
   (C) \( p \rightarrow q \equiv q \rightarrow p \)
   (D) \( p \rightarrow q \equiv \sim q \)

\[ \textbf{1.3 Tautology, Contradiction, Contingency} \]

17. \( \sim (\sim p) \leftrightarrow p \)
   (A) a tautology
   (B) a contradiction
   (C) neither a contradiction nor a tautology
   (D) none of these

18. \( (\sim p \land q) \land (q \land r) \) is a
   (A) tautology
   (B) contingency
   (C) contradiction
   (D) neither tautology nor contradiction

19. Which of the following is a tautology?
   (A) \( p \rightarrow (p \land q) \)
   (B) \( q \land (p \rightarrow q) \)
   (C) \( \sim (p \rightarrow q) \leftrightarrow p \land \sim q \)
   (D) \( (p \land q) \leftrightarrow \sim q \)

20. Which of the following statement is contradiction?
   (A) \( (p \land q) \rightarrow q \)
   (B) \( (p \land \sim q) \land (p \rightarrow q) \)
   (C) \( p \rightarrow (p \land \sim q) \)
   (D) \( (p \land q) \lor \sim q \)

21. Which of the following statement is a contingency?
   (A) \( (p \land \sim q) \lor (\sim p \land \sim q) \)
   (B) \( (p \land q) \leftrightarrow (\sim p \rightarrow \sim q) \)
   (C) \( (\sim q \land p) \lor (p \lor \sim p) \)
   (D) \( (q \rightarrow p) \lor (p \leftrightarrow \sim q) \)

\[ \textbf{1.4 Quantifiers and Quantified Statements} \]

Duality

22. If \( A = \{4, 5, 7, 9\} \), determine which of the following quantified statement is true.
   (A) \( \exists x \in A, \text{ such that } x + 4 = 7 \)
   (B) \( \forall x \in A, x + 1 \leq 10 \)
   (C) \( \forall x \in A, 2x \leq 17 \)
   (D) \( \exists x \in A, \text{ such that } x + 1 > 10 \)

23. Using quantifier the open sentence ‘\( x^2 > 0 \)’ defined on \( N \) is converted into true statement as
   (A) \( \forall x \in N, x^2 > 0 \)
   (B) \( \forall x \in N, x^2 \leq 0 \)
   (C) \( \exists x \in N, \text{ such that } x^2 < 0 \)
   (D) \( \exists x \in N, \text{ such that } x^2 < 0 \)

24. Which of the following quantified statement is false?
   (A) \( \exists x \in N, \text{ such that } x + 5 \leq 6 \)
   (B) \( \forall x \in N, x^2 \leq 0 \)
   (C) \( \exists x \in N, \text{ such that } x - 1 < 0 \)
   (D) \( \exists x \in N, \text{ such that } x^2 - 3x + 2 = 0 \)

25. Given below are four statements along with their respective duals. Which dual statement is not correct?
   (A) \( (p \lor q) \land (r \lor s), (p \land q) \lor (r \land s) \)
   (B) \( (p \lor q) \land (\sim p), (p \land q) \lor (\sim p) \)
   (C) \( (p \land q) \lor s, (p \lor q) \land r \)
   (D) \( (p \lor q) \lor s, (p \land q) \lor s \)

\[ \textbf{1.5 Negation of compound statements} \]

27. Negation of the proposition \( (p \lor q) \land (\sim q \land r) \) is
   (A) \( (p \land q) \lor (q \land r) \)
   (B) \( \sim (p \lor q) \land (\sim q \land r) \)
   (C) \( (p \land q) \lor (q \land r) \)
   (D) \( (p \land q) \land (q \land r) \)

28. The negation of \( p \lor (\sim q \land \sim p) \) is
   (A) \( \sim p \land q \)
   (B) \( p \land \sim q \)
   (C) \( \sim p \land q \)
   (D) \( \sim p \land q \)

29. Which of the following is logically equivalent to \( \sim[p \rightarrow (p \lor \sim q)] \)?
   (A) \( p \lor (\sim p \land q) \)
   (B) \( p \land (\sim p \land q) \)
   (C) \( p \land (p \land \sim q) \)
   (D) \( p \lor (p \land \sim q) \)

30. The negation of the statement, \( \exists x \in R, \text{ such that } x^2 + 3 > 0 \), is
   (A) \( \exists x \in R, \text{ such that } x^2 + 3 < 0 \)
   (B) \( \forall x \in R, x^2 + 3 < 0 \)
   (C) \( \forall x \in R, x^2 + 3 \leq 0 \)
   (D) \( \exists x \in R, \text{ such that } x^2 + 3 = 0 \)
31. The negation of the statement “If Saral Mart does not reduce the prices, I will not shop there any more” is
(A) Saral Mart reduces the prices and still I will shop there.
(B) Saral Mart reduces the prices and I will not shop there.
(C) Saral Mart does not reduce the prices and still I will shop there.
(D) Saral Mart does not reduce the prices or I will shop there.

1.6 Switching Circuit

32. The switching circuit for the statement

\[ p \land (q \lor r) \lor (~p \land s) \]

is
(A) \[ \text{[Diagram]} \]
(B) \[ \text{[Diagram]} \]
(C) \[ \text{[Diagram]} \]
(D) \[ \text{[Diagram]} \]

33. If the symbolic form is

\[ (p \land r) \lor (~q \land ~r) \lor (~p \land ~r) \]

then switching circuit is
(A) \[ \text{[Diagram]} \]
(B) \[ \text{[Diagram]} \]
(C) \[ \text{[Diagram]} \]
(D) \[ \text{[Diagram]} \]
35. The symbolic form of logic for the following circuit is

\[(A) \ (p \lor q) \land (~p \land r \lor ~q) \lor ~r\]
\[(B) \ (p \land q) \land (~p \lor r \land ~q) \lor ~r\]
\[(C) \ (p \land q) \lor [~p \land (r \lor ~q)] \lor ~r\]
\[(D) \ (p \lor q) \lor [~p \land (r \land ~q)] \lor ~r\]

36. The simplified circuit for the following circuit is

\[(A) \sim p \rightarrow \sim q \quad (B) \sim q \rightarrow \sim p \]
\[(C) \ p \rightarrow q \quad (D) \ p \rightarrow \sim q\]

37. The simplified circuit for the following circuit is

\[(A) \quad S_1 \quad S_2 \quad S_3\]
\[(B) \quad S_1 \quad S_2 \quad S_3\]
\[(C) \quad S_1 \quad S_2 \quad S_3\]
\[(D) \quad S_1 \quad S_2 \quad S_3\]

### Competitive Thinking

#### 1.1 Statement, Logical Connectives, Compound Statements and Truth Table

1. Which of the following statement is not a statement in logic?  
   **[MH CET 2005]**
   (A) Earth is a planet.
   (B) Plants are living object.
   (C) \(\sqrt{-9}\) is a rational number.
   (D) I am lying.

2. \(p : \) A man is happy  
   \(q : \) The man is rich.  
   The symbolic representation of “If a man is not rich then he is not happy” is  
   **[MH CET 2004]**
   (A) \(\sim p \rightarrow \sim q\)  
   (B) \(\sim q \rightarrow p\)
   (C) \(p \rightarrow q\)  
   (D) \(p \rightarrow \sim q\)

3. \(p \rightarrow \) Ram is rich  
   \(q \rightarrow \) Ram is successful  
   \(r \rightarrow \) Ram is talented  
   Write the symbolic form of the given statement.  
   Ram is neither rich nor successful and he is not talented  
   **[MH CET 2008]**
   (A) \(\sim p \land \sim q \lor \sim r\)  
   (B) \(\sim p \lor \sim q \land \sim r\)
   (C) \(\sim p \lor \sim q \lor \sim r\)  
   (D) \(\sim p \land \sim q \land \sim r\)

4. Which of the following is not a correct statement?  
   **[Karnataka CET 2014]**
   (A) Mathematics is interesting.  
   (B) \(\sqrt{3}\) is a prime.  
   (C) \(\sqrt{2}\) is irrational.  
   (D) The sun is a star.

5. Let \(p\) be the proposition: Mathematics is interesting and let \(q\) be the proposition: Mathematics is difficult, then the symbol \(p \land q\) means  
   **[Karnataka CET 2001]**
   (A) Mathematics is interesting implies that Mathematics is difficult.  
   (B) Mathematics is interesting implies and is implied by Mathematics is difficult.  
   (C) Mathematics is interesting and Mathematics is difficult.  
   (D) Mathematics is interesting or Mathematics is difficult.
6. Let \( p: \) roses are red and \( q: \) the sun is a star. Then the verbal translation of \( (\neg p) \lor q \) is

(A) Roses are not red and the sun is not a star.
(B) It is not true that roses are red or the sun is not a star.
(C) It is not true that roses are red and the sun is not a star.
(D) Roses are not red or the sun is a star.

7. Let \( p: \) Boys are playing
\( q: \) Boys are happy
the equivalent form of compound statement \( \neg p \lor q \) is

(A) Boys are not playing or they are happy.
(B) Boys are not happy or they are playing.
(C) Boys are playing or they are not happy.
(D) Boys are not playing or they are not happy.

8. If \( p \) and \( q \) are true statements in logic, which of the following statement pattern is true?

(A) \( (p \lor q) \land \neg q \)
(B) \( p \lor \neg q \)
(C) \( p \land \neg q \)
(D) \( \neg p \land q \)

9. If \( p \rightarrow (\neg p \lor q) \) is false, the truth values of \( p \) and \( q \) are respectively

(A) F, T
(B) F, F
(C) T, T
(D) T, F

10. If \( (p \land \neg q) \rightarrow (\neg p \lor r) \) is a false statement, then respective truth values of \( p, q \) and \( r \) are

(A) T, F, F
(B) F, T, T
(C) T, T, T
(D) F, F, F

11. If \( p: \) Every square is a rectangle
\( q: \) Every rhombus is a kite then truth values of \( p \rightarrow q \) and \( p \leftrightarrow q \) are _______ and _______ respectively.

(A) F, F
(B) T, F
(C) F, T
(D) T, T

12. The contrapositive of \( (p \lor q) \rightarrow r \) is

(A) \( \neg r \rightarrow \neg p \land \neg q \)
(B) \( \neg r \rightarrow (p \lor q) \)
(C) \( r \rightarrow (p \lor q) \)
(D) \( p \rightarrow (q \lor r) \)

13. The converse of the contrapositive of \( p \rightarrow q \) is

(A) \( \neg p \rightarrow q \)
(B) \( p \rightarrow \neg q \)
(C) \( \neg p \rightarrow \neg q \)
(D) \( \neg q \rightarrow p \)

14. If Ram secures 100 marks in maths, then he will get a mobile. The converse is

(A) If Ram gets a mobile, then he will not secure 100 marks in maths.
(B) If Ram does not get a mobile, then he will secure 100 marks in maths.
(C) If Ram will get a mobile, then he secures 100 marks in maths.
(D) None of these

15. Let \( p: \) A triangle is equilateral, \( q: \) A triangle is equiangular, then inverse of \( q \rightarrow p \) is

(A) If a triangle is not equilateral then it is not equiangular.
(B) If a triangle is not equiangular then it is not equilateral.
(C) If a triangle is equiangular then it is not equilateral.
(D) If a triangle is equiangular then it is equilateral.

16. If it is raining, then I will not come. The contrapositive of this statement will be

(A) If I will come, then it is not raining
(B) If I will not come, then it is raining
(C) If I will not come, then it is not raining
(D) If I will come, then it is raining

17. The contrapositive of the converse of the statement “If \( x \) is prime number then \( x \) is odd" is

(A) If \( x \) is not an odd number then \( x \) is not a prime number
(B) If \( x \) is not a prime number then \( x \) is not an odd
(C) If \( x \) is not a prime number then \( x \) is odd
(D) If \( x \) is a prime number then it is not odd
1.2 Statement Pattern, Logical Equivalence, and Algebra of Statements

18. The logically equivalent statement of \( p \leftrightarrow q \) is

- (A) \( (p \land q) \lor (q \rightarrow p) \)
- (B) \( (p \land q) \rightarrow (p \lor q) \)
- (C) \( (p \rightarrow q) \land (q \rightarrow p) \)
- (D) \( (p \land q) \lor (p \land q) \)

19. \( \sim p \land q \) is logically equivalent to

- (A) \( p \rightarrow q \)
- (B) \( q \rightarrow p \)
- (C) \( \sim(p \rightarrow q) \)
- (D) \( \sim(q \rightarrow p) \)

20. \( (p \land q) \lor (\sim q \land p) = \)

- (A) \( q \lor p \)
- (B) \( p \)
- (C) \( \sim q \)
- (D) \( p \land q \)

21. The Boolean Expression \( (p \land \sim q) \lor q \lor (\sim p \land q) \) is equivalent to:

- (A) \( p \land q \)
- (B) \( p \lor q \)
- (C) \( \sim q \)
- (D) \( \sim p \land q \)

22. The statement \( p \rightarrow (q \rightarrow p) \) is equivalent to

- (A) \( p \rightarrow (p \land q) \)
- (B) \( p \rightarrow (p \leftrightarrow q) \)
- (C) \( p \rightarrow (p \rightarrow q) \)
- (D) \( p \rightarrow (p \lor q) \)

23. The statement \( p \rightarrow (\sim q) \) is equivalent to

- (A) \( q \rightarrow p \)
- (B) \( \sim q \lor \sim p \)
- (C) \( p \land \sim q \)
- (D) \( \sim q \rightarrow p \)

1.3 Tautology, Contradiction, Contingency

24. Which of the following is not true for any two statements \( p \) and \( q \)?

- (A) \( \sim[p \lor (\sim q)] \equiv \sim p \land q \)
- (B) \( (p \lor q) \lor (\sim q) \) is a tautology
- (C) \( \sim(p \land \sim p) \) is a tautology
- (D) \( \sim(p \lor q) \equiv \sim p \lor \sim q \)

25. The proposition \( (p \rightarrow \sim p) \land (\sim p \rightarrow p) \) is a

- (A) Neither tautology nor contradiction
- (B) Tautology
- (C) Tautology and contradiction
- (D) Contradiction

26. \( (p \land \sim q) \land (\sim p \land q) \) is a

- (A) Tautology
- (B) Contradiction
- (C) Tautology and contradiction
- (D) Contingency

27. Which of the following statements is a tautology?

- (A) \( (\sim q \land p) \land q \)
- (B) \( (\sim q \land p) \land (p \land \sim p) \)
- (C) \( (\sim q \land p) \lor (p \lor \sim p) \)
- (D) \( (p \land q) \land (\sim (p \land q)) \)

28. The only statement among the following i.e., a tautology is

- (A) \( A \land (A \lor B) \)
- (B) \( A \lor (A \land B) \)
- (C) \( [A \land (A \rightarrow B)] \rightarrow B \)
- (D) \( B \rightarrow [A \land (A \rightarrow B)] \)

29. The false statement in the following is

- (A) \( p \land (\sim p) \) is a contradiction
- (B) \( p \lor (\sim p) \) is a tautology
- (C) \( \sim (\sim p) \leftrightarrow p \) is tautology
- (D) \( (p \rightarrow q) \leftrightarrow (\sim q \rightarrow \sim p) \) is a contradiction

30. The statement \( \sim(p \leftrightarrow q) \)

- (A) a tautology
- (B) a fallacy
- (C) equivalent to \( p \leftrightarrow q \)
- (D) equivalent to \( \sim p \leftrightarrow q \)

1.4 Quantifier and Quantified Statements

31. Which of the following quantified statement is true?

- (A) The square of every real number is positive
- (B) There exists a real number whose square is negative
- (C) There exists a real number whose square is not positive
- (D) Every real number is rational

1.5 Negation of compound statements

32. The negation of \( q \lor (\sim (p \land r)) \) is

- (A) \( \sim q \land (\sim p \lor r) \)
- (B) \( \sim q \land (p \land r) \)
- (C) \( \sim q \lor (p \land r) \)
- (D) \( \sim q \lor (p \land r) \)
33. The negation of \((p \lor \neg q) \land q\) is

\[\text{[Kerala (Engg.) 2011]}\]

(A) \((\neg p \lor q) \land \neg q\)
(B) \((p \land \neg q) \lor q\)
(C) \((\neg p \land q) \lor \neg q\)
(D) \((p \land \neg q) \lor \neg q\)

34. Negation of the statement ‘A is rich but silly’ is

\[\text{[MH CET 2006]}\]

(A) Either A is not rich or not silly.
(B) A is poor or clever.
(C) A is rich or not silly.
(D) A is either rich or silly.

35. The negation of the statement given by “He is rich and happy” is

\[\text{[MH CET 2006]}\]

(A) He is not rich and not happy
(B) He is rich but not happy
(C) He is not rich but happy
(D) Either he is not rich or he is not happy

36. Let \(p\) : 7 is not greater than 4 and \(q\) : Paris is in France
be two statements. Then, \(\neg (p \lor q)\) is the statement

\[\text{[Kerala (Engg.) 2010]}\]

(A) 7 is greater than 4 or Paris is not in France.
(B) 7 is not greater than 4 and Paris is not in France.
(C) 7 is not greater than 4 and Paris is in France.
(D) 7 is greater than 4 and Paris is not in France.

37. The negation of \(\neg s \lor (\neg r \land s)\) is equivalent to

\[\text{[JEE (Main) 2015]}\]

(A) \(s \land \neg r\)
(B) \(s \land (r \lor \neg s)\)
(C) \(s \lor (r \land \neg s)\)
(D) \(s \land r\)

38. Which of the following is always true?

\[\text{[Karnataka CET 1998]}\]

(A) \((p \rightarrow q) \equiv \neg q \rightarrow \neg p\)
(B) \(\neg (p \lor q) \equiv p \lor \neg q\)
(C) \(\neg (p \rightarrow q) \equiv p \land \neg q\)
(D) \(\neg (p \lor q) \equiv \neg p \lor \neg q\)

39. Negation of \(\neg (p \rightarrow q)\) is

\[\text{[MH CET 2009]}\]

(A) \(p \lor \neg q\)
(B) \(\neg p \lor q\)
(C) \(p \land \neg q\)
(D) \(\neg p \lor q\)

40. The negation of \(p \rightarrow (\neg p \lor q)\) is

\[\text{[Karnataka CET 2011]}\]

(A) \(p \lor (p \lor \neg q)\)
(B) \(p \rightarrow \neg(p \lor q)\)
(C) \(p \lor q\)
(D) \(p \land \neg q\)

41. Negation of \((p \land q) \rightarrow (\neg p \lor r)\) is

\[\text{[MH CET 2005]}\]

(A) \((p \lor q) \land (p \land \neg r)\)
(B) \((p \lor q) \lor (p \land \neg r)\)
(C) \((p \land q) \land (p \land \neg r)\)
(D) \((p \lor q) \lor (p \land \neg r)\)

42. Negation of \(p \leftrightarrow q\) is

\[\text{[MH CET 2005]}\]

(A) \((p \land q) \lor (p \land q)\)
(B) \((p \land q) \lor (q \land \neg p)\)
(C) \((\neg p \land q) \lor (q \land p)\)
(D) \((p \land q) \lor (\neg q \land p)\)

43. The negation of the proposition “If 2 is prime, then 3 is odd” is

\[\text{[Karnataka CET 2007]}\]

(A) If 2 is not prime, then 3 is not odd.
(B) 2 is prime and 3 is not odd.
(C) 2 is not prime and 3 is odd.
(D) If 2 is not prime then 3 is odd.

44. Let \(S\) be a non-empty subset of \(R\). Consider the following statement:
\(p\) : There is a rational number \(x \in S\) such that \(x > 0\).
Which of the following statements is the negation of the statement \(p\)?

\[\text{[AIEEE 2010]}\]

(A) There is a rational number \(x \in S\) such that \(x \leq 0\)
(B) There is no rational number \(x \in S\) such that \(x \leq 0\)
(C) Every rational number \(x \in S\) satisfies \(x \leq 0\)
(D) \(x \in S\) and \(x \leq 0 \rightarrow x\) is not rational

1.6 Switching circuit

45. When does the current flow through the following circuit.

\[\text{[Karnataka CET 2002]}\]

(A) \(p, q\) should be closed and \(r\) is open
(B) \(p, q, r\) should be open
(C) \(p, q, r\) should be closed
(D) none of these
46. The following circuit represent symbolically in logic when the current flow in the circuit.

Which of the symbolic form is correct?  
[Karnataka CET 1999]
(A) \((\neg p \lor q) \lor (p \lor \neg q)\)
(B) \((\neg p \land p) \land (\neg q \land q)\)
(C) \((\neg p \land \neg q) \land (q \land p)\)
(D) \((\neg p \land q) \lor (p \land \neg q)\)

47. If

then the symbolic form is  
[MH CET 2009]
(A) \((p \lor q) \land (p \lor r)\)
(B) \((p \land q) \lor (p \lor r)\)
(C) \((p \land q) \land (p \land r)\)
(D) \((p \land q) \land r\)

48. Simplified logical expression for the following switching circuit is  
[MH CET 2010]
(A) \(p\)
(B) \(q\)
(C) \(p'\)
(D) \(p \land q\)

49. Symbolic form of the given switching circuit is equivalent to  
[MH CET 2016]
(A) \(p \lor \neg q\)
(B) \(p \land \neg q\)
(C) \(p \leftrightarrow q\)
(D) \(\neg(p \leftrightarrow q)\)
Classical Thinking

1. ‘Bombay is the capital of India’ is a statement. The other options are exclamatory and interrogative sentences.

2. ‘Two plus two is four’ is a statement. The other options are imperative sentences.

3. Even though 2 = 3 is false, it is a statement in logic with truth value F.

5. ~q: Ram studies on holiday, ‘and’ is expressed by ‘&&’ symbol.

6. p: There are clouds in the sky, ~q: It is not raining, ‘and’ is expressed by ‘&&’ symbol.

7. ~p: The sun has not set, ~q: The moon has not risen, ‘or’ is expressed by ‘||’ symbol.

8. ~p: Rohit is short, ‘or’ is expressed by ‘||’ symbol, ‘and’ is expressed by ‘&&’ symbol.

Hints

9. p: Candidates are present,
q: Voters are ready to vote
r: Ballot papers \( \Rightarrow \sim r \): no Ballot papers
‘and’ and ‘but’ are represented by ‘&&’ symbol.

10. ~p: She is not beautiful, ‘\( \vee \)’ indicates ‘or’.

11. ~p: Ram is not lazy, ~q: Ram does not fail in the examination, ‘\( \vee \)’ indicates ‘or’.

15. “Implies” is expressed as ‘\( \Rightarrow \)’.
\[ \therefore \text{symbolic form is } p \Rightarrow q \]

16. (\( \sim d \): Driver is not drunk) implies (\( \sim a \): He cannot meet with an accident).

17. “if and only if” is expressed as ‘\( \Leftrightarrow \)’.
\[ \therefore \text{symbolic form is } a \Leftrightarrow b \]

19. p: A, B, C, are distinct points
q: Points are collinear
r: Points form a triangle
\[ \therefore p \text{ implies } (q \text{ or } r) \text{ i.e. } p \Rightarrow (q \vee r) \]

20. ‘m \Rightarrow n’ means ‘If m then n’;
\[ \therefore \text{option (C) is correct.} \]
23. Let $p: x^2$ is not even,  
$\therefore$ If $x$ is not even then $x^2$ is not even  
Converse of $p \rightarrow q$ is $q \rightarrow p$  
i.e., If $x$ is not even then $x^2$ is not even  
24. Converse of $p \rightarrow q$ is $q \rightarrow p$.  
25. Let $p: x > y$  
$q: x + a > y + a$  
Converse of $p \rightarrow q$ is $q \rightarrow p$  
i.e., If $x + a > y + a$, then $x > y$  
26. Let $p$: You access the internet  
$q$: You have to pay the charges  
Given statement is written symbolically as,  
$p \rightarrow q$  
Inverse of $p \rightarrow q$ is $\neg p \rightarrow \neg q$  
i.e. If you do not access the internet then you  
do not have to pay the charges.  
27. Contrapositive of $p \rightarrow q$ is $\neg q \rightarrow \neg p$.  
28. $\neg p$: Sita does not get promotion and ‘$\iff$’ symbol indicates ‘if and only if’.  
33. $r$: It is raining, $c$: I will go to college.  
The given statement is $r \iff c \equiv \neg c \rightarrow \neg r$  
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40. Option (C) is a true statement, since, $x = 3 \in \mathbb{N}$ satisfies $x + 5 = 8$.  
41. Option (D) is the required true statement since  
$x = 6 \in \mathbb{W}$ satisfies $x^2 - 4 = 32$  
43. $p$: Manoj has the job, $q$: he is not happy  
Symbolic form is $p \land q$.  
Its dual is $p \lor q$.  
$\therefore$ Manoj has the job or he is not happy.  
44. $(p \land q) \equiv (p \lor q)$  
45. $(p \lor (\neg q)) \equiv (p \land (\neg q)) \equiv (p \land q)$  
46. $p$: I like Mathematics  
$q$: I like English.  
$\therefore$ Option (D) is correct.  
47. We know that,  
$p \iff q \equiv (p \rightarrow q) \land (q \rightarrow p)$  
$\therefore (p \iff q) \equiv (p \lor q) \lor (\neg q \lor p)$  
...[By Demorgan’s Law]  
$\equiv (p \land (\neg q)) \lor (q \land \neg p)$  
...[i.e. $\neg (p \rightarrow q) = p \land \neg q$]  
48. $p$: It is Sunday  
$q$: It is a holiday  
$\therefore$ Symbolic form $p \rightarrow q$  
$(p \rightarrow q) \equiv p \land q$  
i.e. It is Sunday, but it is not a holiday  
49. Given statement is ‘$\forall x \in \mathbb{N}, x + 5 > 4$’  
$\therefore \exists x \in \mathbb{N}$, such that $x + 5 \leq 4$  
i.e., there exists a natural number $x$, for which $x + 5 \leq 4$  
51. Current will flow in the circuit if switch $p$ and $q$ are closed or switch $r$ is closed.  
It is represented by  
$(p \land q) \lor r$.  
$\therefore$ option (A) is correct.  

Critical Thinking  
1. ‘Incorrect statement’ means a statement in logic with truth value false.  
Options (A) and (C) are not statements in logic.  
Option (D) has truth value True.  
Option (B) is a statement in logic with truth value false.
2. p: One being lucky,  
q: One should stop working  
\therefore Symbolic form: (p \lor \neg p) \land \neg q

3. p: Physics is interesting.  
q: Physics is difficult.  
\therefore Symbolic form: \neg (\neg p \lor q)

4. p: Intelligent persons are polite.  
q: Intelligent persons are helpful.  
\therefore Symbolic form: \neg (\neg p \land \neg q)

5. \neg p \land (q \lor \neg r) and (p \to q) \land r  
\therefore \neg T \land (T \lor \neg F) and (T \to T) \land F  
\Rightarrow F \land (T \lor T) and (T \land F)  
\Rightarrow F \land T and T \land F \Rightarrow F and F

6. (\neg p \lor q) \iff (\neg (p \land q)) and \neg p \iff (p \to \neg q)  
\therefore (\neg F \lor F) \iff (\neg (F \land F)) and \neg F \iff (F \to \neg F)  
\Rightarrow (T \lor F) \iff \neg F and T \iff (F \to T)  
\Rightarrow T \iff T and T \iff T  
\Rightarrow T and T

7. (p \to q) \iff (\neg q \to \neg p) and (\neg p \lor q) \land (\neg q \lor p)  
\therefore (T \to F) \iff (\neg F \to \neg T) and (\neg T \lor F) \land (\neg F \lor T)  
\Rightarrow F \iff (T \to F) and (F \lor F) \land (T \lor T)  
\Rightarrow F \iff F and F \land T \Rightarrow T and F

8. p \land q \equiv F \land T \equiv F  
p \lor \neg q \equiv F \lor \neg T \equiv F \lor T  
q \to p \equiv T \to F \equiv F  
p \to q \equiv F \equiv T

9. \neg p \to \neg q \equiv \neg F \to \neg T \equiv \neg T \equiv F \equiv T  
p \to (q \land p) \equiv F \to (T \land F) \equiv F \to F \equiv T  
p \to \neg q \equiv F \to \neg T \equiv F \to F \equiv T  
q \to \neg p \equiv T \to \neg F \equiv T \equiv T

10. Consider option (C)  
\( (p \lor q) \land (p \lor r) \equiv (T \lor T) \land (T \lor F) \equiv T \land T \equiv T \).  
\therefore option (C) is correct.

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<th>p</th>
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Alternate Method:  
\neg q \lor p: F  
\therefore \neg q \text{ is } F, p \text{ is } F  
i.e., q \text{ is } T, p \text{ is } F  
\therefore p \to q \equiv F \equiv T \equiv T

12. p: Seema solves a problem  
q: She is happy  
i. p \to q  
ii. \neg p \to \neg q  
iii. \neg q \to \neg p  
iv. q \to p  
(i) and (iii) have the same meaning,  
(ii) and (iv) have the same meaning.

13. i. b \to r  
ii. \neg b \to \neg r  
iii. r \to b  
iv. \neg r \to \neg b  
(i) and (iv) are the same and (ii) and (iii) are the same.

14. p \land (p \to q)  
\equiv p \land (\neg p \lor q) \text{ ...[Conditional law]}  
\equiv (p \land \neg p) \lor (p \land q) \text{ ...[Distributive law]}  
\equiv F \lor (p \land q) \text{ ...[Complement law]}  
\equiv p \land q \text{ ...[Identity law]}

15. \neg (p \lor q) \lor (\neg p \lor q)  
\equiv (\neg p \land \neg q) \lor (\neg p \land q)  
\equiv \neg p \land (\neg q \lor q)  
\equiv \neg p \land T  
\equiv \neg p

16. (\neg q) \to (\neg p) is contrapositive of p \to q and hence both are logically equivalent of each other.

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<th>p</th>
<th>\neg p</th>
<th>(\neg p) \iff p</th>
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All the entries in the last column of the above truth table is T.  
\therefore (\neg p) \iff p \text{ is a tautology.}

18.  
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\therefore Given statement is contradiction.
19. Consider option (C)

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<th>(p→q)↔(p∧q)</th>
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**: option (C) is correct.

20. Consider option (B)

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**: option (B) is correct.

21. Consider option (B)

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**: option (B) is correct.

22. Since, \( x = 4, 5, 7, 9 \) satisfies \( x + 1 \leq 10 \)

**: Option (B) is correct.

23. Option (A) is the true statement since square of every natural number is positive.

24. Option (C) is false, since for every natural number the statement \( x - 1 \geq 0 \) is always true.

25. Dual of \( (p \lor q) \lor s \) is \( (p \land q) \land s \).

27. Negation of \( (p \lor q) \land (~q \land r) \) is 

\[
\neg[(p \lor q) \land (~q \land r)]
\]

\[
\equiv \neg(p \lor q) \lor (q \land r)
\]

\[
\equiv (q \land r) \lor \neg(p \lor q)
\]

\[
\equiv (q \land r) \lor (p \land \neg q)
\]

\[
\equiv (p \land q) \lor (p \land \neg q)
\]

28. \( [p \lor (q \land ~p)]\)

\[
\equiv p \lor (q \land ~p) \] ...[By De Morgan’s law]

\[
\equiv p \lor [\neg(p \land q) \lor (p \land q)]
\]

\[
\equiv p \lor (p \land q)
\]

\[
\equiv p \lor (p \land q)
\]

\[
\equiv q \lor (p \land q)
\]

\[
\equiv (q \lor p) \land q
\]

\[
\equiv (p \lor q) \land q
\]

**: The symbolic representation of the given statement is \( \sim q \rightarrow \sim p \).

30. \( \sim [\exists x \in \mathbb{R}, \text{ such that } x^2 + 3 > 0] \)

\[
\equiv \forall x \in \mathbb{R}, x^2 + 3 \leq 0
\]

31. \( p: \text{ Saral Mart does not reduce the prices.} \)

\( q: \text{ I will not shop there any more.} \)

Symbolic form is \( p \rightarrow q \)

\( (p \rightarrow q) \equiv p \land \sim q \)

i.e. Saral Mart does not reduce the prices and still I will shop there.

36. The symbolic form of circuit is 

\( (p \land q) \lor (p \land \sim q) \equiv (p \lor p) \land q \)

\( \equiv T \land q \)

\( \equiv q \)

37. The symbolic form of circuit is 

\( [(\sim p \land \sim q) \lor p \lor q] \land r \)

\( \equiv [(\sim p \lor q) \lor (p \lor q)] \land r \)

\( \equiv T \land r \)

\( \equiv r \)

**Competitive Thinking**

2. Man is not rich : \( \sim q \)

Man is not happy : \( \sim p \)

**: The symbolic representation of the given statement is \( \sim q \rightarrow \sim p \).

3. \( \sim p: \text{ Ram is not rich} \)

\( \sim q: \text{ Ram is not successful} \)

\( \sim r: \text{ Ram is not talented} \)

**: The symbolic form of the given statement is 

\( \sim p \land \sim q \land \sim r \).

4. “Not a correct statement” means it is a statement whose truth value is false.

Option (A) is not a statement.

Options (C) and (D) are statements with truth value true.

\( \sqrt{3} \) is a prime* is false statement.

Hence, option (B) is correct.

5. The symbol \( p \land q \) means 

Mathematics is interesting and Mathematics is difficult.

6. \( p: \text{ roses are red} \)

\( q: \text{ The sun is a star} \)

\( \sim p \lor q: \text{ roses are not red or the sun is a star} \).

7. \( \sim p: \text{ Boys are not playing} \)

The symbol ‘\( \lor \)’ means ‘or’. 
8. Consider option (C),
   \((p \land \sim q) \rightarrow q \equiv (T \land \sim T) \rightarrow T\)
   \(\equiv (T \land F) \rightarrow T\)
   \(\equiv F \rightarrow T\)
   \(\equiv T\)
   \(\therefore\) option (C) is correct.

9.

\[
\begin{array}{c|c|c|c|c|c}
 p & q & \sim p & \sim p \lor q & p \rightarrow (\sim p \lor q) \\
 T & T & F & F & T \\
 T & F & F & F & F \\
 F & T & T & T & T \\
 F & F & T & T & T \\
\end{array}
\]

\(\therefore\) From the table \(p \rightarrow (\sim p \lor q)\) is false when \(p\) is true and \(q\) is false.

10. Since, \((p \land \sim q) \rightarrow (\sim p \lor r) \equiv F\)
    \(\Rightarrow p \land \sim q \equiv T\) and \(\sim p \lor r \equiv F\)
    \(\Rightarrow p = T\), \(\sim q = T\) and \(\sim p = F\), \(r = F\)
    \(\Rightarrow p = T\), \(q = F\), \(r = F\)
    \(\therefore\) The truth values of \(p\), \(q\) and \(r\) are \(T\), \(F\), \(F\) respectively.

11. Since, both the given statements \(p\) and \(q\) have truth values \(T\),
    \(\therefore p \rightarrow q \equiv T \rightarrow T \equiv T\), and
    \(p \leftrightarrow q \equiv T \leftrightarrow T \equiv T\).

12. Contrapositive of \((p \lor q) \rightarrow r\) is
    \(\sim r \rightarrow \sim(p \lor q)\) i.e. \(\sim r \sim p \land \sim q\)

13. Given \(p \rightarrow q\)
    Its contrapositive is \(\sim q \rightarrow \sim p\)
    and its converse is \(\sim p \rightarrow \sim q\)

14. Let \(p : \) Ram secures 100 marks in maths
    \(q : \) Ram will get a mobile
    Converse of \(p \rightarrow q\) is \(q \rightarrow p\)
    i.e., If Ram will get a mobile, then he secures 100 marks in maths.

15. Inverse of \(q \rightarrow p\) is \(\sim q \rightarrow \sim p\)
    i.e., If a triangle is not equiangular then it is not equilateral.

16. Let \(p : \) It is raining
    \(q : \) I will not come
    Contrapositive of \(p \rightarrow q\) is \(\sim q \rightarrow \sim p\)
    i.e., If I will come, then it is not raining.

17. Let \(p : x\) is prime number
    \(q : x\) is odd
    \(\therefore\) Statement is \(p \rightarrow q\)
    Converse of \(p \rightarrow q\) is \(q \rightarrow p\)
    Contrapositive of \(q \rightarrow p\) is \(\sim p \rightarrow \sim q\).

19.

\[
\begin{array}{c|c|c|c|c|c|c}
 p & q & \sim p & \sim p \land q & q \rightarrow p & \sim(q \rightarrow p) \\
 T & T & F & T & F & T \\
 T & F & F & F & T & F \\
 F & T & T & T & F & T \\
 F & F & T & T & F & T \\
\end{array}
\]

The entries in the columns 4 and 6 are identical.

\(\therefore\) \(\sim p \land q \equiv \sim(q \rightarrow p)\)

20. \((p \land q) \lor (\sim q \land p) \equiv (p \land q) \lor (p \land \sim q)\)
    \(\equiv p \land (q \lor \sim q)\)
    \(\equiv p \land T \equiv p\)

21. \((p \land \sim q) \lor q \lor (\sim p \land q)\)
    \(\equiv [(p \land q) \land (q \lor q)] \lor (\sim p \land q)\)
    \(\equiv [(p \land q) \land T] \lor (\sim p \land q)\)
    \(\equiv (p \land q) \lor (\sim p \land q)\)
    \(\equiv (p \lor q \lor \sim p) \land (p \lor q \lor q)\)
    \(\equiv (T \lor q) \land (p \lor q) \equiv T \land (p \lor q)\)
    \(\equiv p \lor q\)

22.

\[
\begin{array}{c|c|c|c|c|c|c}
 p & q & q \rightarrow p & (p \rightarrow (q \lor p)) & q \lor p & p \rightarrow (q \lor p) \\
 T & T & T & T & T & T \\
 T & F & F & F & T & F \\
 F & T & F & T & T & T \\
 F & F & T & T & F & T \\
\end{array}
\]

The entries in the columns 4 and 6 are identical.

\(\therefore\) \(p \rightarrow (q \rightarrow p) \equiv p \rightarrow (p \lor q)\)

23. \(p \rightarrow (\sim q) \equiv \sim p \lor q\)
    \(\equiv \sim q \lor \sim p\)

24. \(p \lor p \equiv p\) is not true as it contradicts
    De Morgan’s law.
    \(\therefore\) option (D) is not true.

25.

\[
\begin{array}{c|c|c|c|c|c}
 p & \sim p & p \rightarrow \sim p & ~p \rightarrow p & (p \rightarrow \sim p) \land (\sim p \rightarrow p) \\
 T & F & F & T & F \\
 F & T & F & T & F \\
\end{array}
\]

26.

\[
\begin{array}{c|c|c|c|c|c|c}
 p & q & \sim p & \sim q & (p \land q) & (\sim p \land q) & (p \land \sim q) \land (\sim p \land q) \\
 T & T & F & F & F & F & F \\
 T & F & F & T & F & F & F \\
 F & T & T & F & T & F & T \\
 F & F & T & T & F & F & F \\
\end{array}
\]

\(\therefore\) Given statement is contradiction.
27. Since, p ∨ ~p ≡ T
   ∴ (~q ∧ p) ∨ (p ∨ ~p) ≡ (~q ∧ p) ∨ T ≡ T
   ∴ (~q ∧ p) ∨ (p ∨ ~p) is a tautology.

28. Consider option (C)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>A → B</th>
<th>A ∧ (A → B)</th>
<th>[A ∧ (A → B)] → B</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>F</td>
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<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>T</td>
</tr>
</tbody>
</table>

∴ option (C) is correct.

29. p → q is logically equivalent to ~q → ~p
   ∴ (p → q) ↔ (~q → ~p) is tautology
   But, it is given contradiction.
   Hence, it is false statement.

30. The entries in the columns 5 and 6 are identical.
   ∴ ~ (p ↔ ~q) ≡ p ↔ q

31. Option (C) is the correct answer since there exists a real number x = 0, such that x^2 = 0.
   Zero is neither positive nor negative.

32. Negation of q ∨ ~ (p ∧ r) is
   ~[q ∨ ~ (p ∧ r)] ≡ ~q ∧ ~ (~ (p ∧ r))
   ≡ ~q ∧ ~p ∧ ~r

33. ~[(p ∨ ~q) ∧ q] ≡ ~ (p ∨ ~q) ∨ ~q
   ....[De Morgan’s Law]
   ≡ (~p) ∨ (~ (~q)) ∨ ~q
   ≡ (~p) ∨ ~q

34. p : A is rich, q : A is silly
   ∴ ~ (p ∧ q) ≡ ~p ∨ ~q

35. ~ (p ∧ q) ≡ ~p ∨ ~q

36. ~ (p ∨ q) ≡ (~p) ∧ (~q)
   i.e., 7 is greater than 4 and Paris is not in France.

37. ~ [~s ∨ (~r ∧ s)]
   ≡ (~ (~s)) ∧ (~ (~r ∧ s)) ....[De Morgan’s Law]
   ≡ s ∧ (~ r ∨ ~s)
   ≡ (s ∧ r) ∨ (s ∧ ~s) ....[Distributive property]

≡ (s ∧ r) ∨ F ....[Complement law]
≡ s ∧ r ....[Identity law]

38. p → q ≡ ~p ∨ q
   ∴ ~ (p → q) ≡ p ∧ ~ q

39. Since, p → q ≡ ~p ∨ q
   ∴ ~p → q ≡ p ∨ q
   ∴ ~ (~p → q) ≡ (~p ∨ q)
   ≡ ~ p ∧ ~ q

40. ~ [p → (~p ∨ q)] ≡ p ∧ (~ (~p ∨ q)]
   ≡ p ∧ (~p ∧ ~ q)
   ≡ (p ∧ p) ∧ ~ q
   ≡ p ∧ q

41. Since, p → q ≡ ~p ∨ q
   ∴ ~ [(p ∧ q) → (~p ∨ r)]
   ≡ ~ [~ (~p ∧ q) ∨ (~ p ∨ r)]
   ≡ (~p ∨ ~ q) ∧ (~ p ∨ r)
   ≡ (p ∧ q) ∧ (p ∧ ~ r)

42. Let p : 2 is prime, q : 3 is odd
   ∴ Symbolic form p → q
   ∴ ~ (p → q) ≡ p ∧ ~ q
   i.e., 2 is prime and 3 is not odd.

43. Given statement is
   ∃ x ∈ S, such that x > 0
   ∴ ~ ( ∃ x ∈ S, such that x > 0 )
   ≡ ∀ x ∈ S, x ≤ 0
   i.e., Every rational number x ∈ S satisfies x ≤ 0.

44. The current will flow through the circuit if p, q, r are closed or p, q’, r are closed.
   ∴ option (C) is the correct answer.

45. Let p : switch s1 is closed.
   q : switch s2 is closed.
   ~ p : switch s1 is open
   ~ q : switch s2 is open
   The current can flow in the circuit if either s1’ and s2 are closed or s1 and s2’ are closed.
   It is represented by (~p ∧ q) ∨ (p ∧ ~ q).

46. The symbolic form of the given circuit is
   (p ∨ ~q) ∧ q ≡ T ∧ q
   ≡ q

47. Symbolic form of the circuit is
   (p ∧ ~q) ∨ (~p ∧ q) ≡ (p ∧ ~q) ∨ (q ∧ ~ p)
   ≡ ~ (p ↔ q)
1. Which of the following is not a statement in logic?
   (A) Every set is a finite set.
   (B) 2 + 3 < 6
   (C) \( x + 3 = 10 \)
   (D) Zero is a complex number.

2. If \( p \rightarrow (q \lor r) \) is false, then the truth values of \( p, q \) and \( r \) are respectively
   (A) T, F, F
   (B) F, F, F
   (C) F, T, F
   (D) T, T, F

3. The contrapositive of \( (\neg p \land q) \rightarrow \neg r \) is
   (A) \( (p \land q) \rightarrow r \)
   (B) \( p \lor \neg (p \land q) \)
   (C) \( \neg p \land \neg q \)
   (D) none of these

4. If \( p: \text{Rohit is tall}, q: \text{Rohit is handsome} \), then
   the statement ‘Rohit is tall or he is short and handsome’ can be written symbolically as
   (A) \( p \lor \neg (p \land q) \)
   (B) \( p \land \neg (p \lor q) \)
   (C) \( p \lor (p \land \neg q) \)
   (D) \( \neg p \land (\neg p \land \neg q) \)

5. The converse of the statement, “If \( x \) is a complex number, then \( x \) is a negative number” is
   (A) If \( \neg x \) is not a complex number, then \( x \) is not a negative number.
   (B) If \( x \) is a negative number, then \( \sqrt{x} \) is a complex number.
   (C) If \( x \) is not a negative number, then \( \sqrt{x} \) is not a complex number.
   (D) If \( \sqrt{x} \) is a real number, then \( x \) is a positive number.

6. Which of the following statements is a contingency?
   (A) \( \neg (p \land q) \land (q \land r) \land (p \lor r) \land (q \lor r) \)
   (B) \( (p \rightarrow q) \lor (q \rightarrow p) \)
   (C) \( (p \land q) \rightarrow r \)
   (D) \( (q \rightarrow r) \lor (r \rightarrow p) \)

7. Which of the following is a contradiction?
   (A) \( p \land q \land \neg (p \lor q) \)
   (B) \( p \lor \neg (p \land q) \)
   (C) \( p \rightarrow q \rightarrow p \)
   (D) none of these

8. Statement-1: \( \neg (p \leftrightarrow q) \) is equivalent to \( p \leftrightarrow q \).
   Statement-2: \( \neg (p \leftrightarrow q) \) is a tautology.
   (A) Statement-1 is true, statement-2 is true.
   (B) Statement-1 is true, statement-2 is false.
14. The inverse of the proposition \((p \land \sim q) \rightarrow r\) is
   (A) \(\sim r \rightarrow \sim p \lor q\)  
   (B) \(\sim p \lor q \rightarrow \sim r\)  
   (C) \(r \rightarrow p \land \sim q\)  
   (D) \(\sim p \land q \rightarrow \sim r\)

15. The negation of the statement \(\forall x \in \mathbb{N}, x + 1 > 2\) is
   (A) \(\forall x \notin \mathbb{N}, x + 1 < 2\)
   (B) \(\exists x \in \mathbb{N}, \text{ such that } x + 1 > 2\)
   (C) \(\forall x \in \mathbb{N}, x + 1 \leq 2\)
   (D) \(\exists x \in \mathbb{N}, \text{ such that } x + 1 \leq 2\)

**Answers to Evaluation Test**

1. (C)  2. (A)  3. (C)  4. (A)  
5. (B)   6. (C)  7. (A)  8. (B)  
9. (C)   10. (A) 11. (B)  12. (D)  
13. (B)  14. (B)  15. (D)
QUESTION PAPER : MHT CET 2016

1. Let $X \sim B(n, p)$, if $E(X) = 5$ and $Var(X) = 2.5$ then $P(X < 1) =$
   (A) $\left(\frac{1}{2}\right)^{11}$ (B) $\left(\frac{1}{2}\right)^{10}$
   (C) $\left(\frac{1}{2}\right)^{6}$ (D) $\left(\frac{1}{2}\right)^{9}$

2. Derivative of $\tan^{-1}\left(\frac{x}{\sqrt{1-x^2}}\right)$ with respect to $\sin^{-1}(3x - 4x^3)$ is
   (A) $\frac{1}{\sqrt{1-x^2}}$ (B) $\frac{3}{\sqrt{1-x^2}}$
   (C) 3 (D) $\frac{1}{3}$

3. The differential equation of the family of circles touching Y-axis at the origin is
   (A) $\left(x^2 + y^2\right)\frac{dy}{dx} - 2xy = 0$
   (B) $x^2 - y^2 + 2xy \frac{dy}{dx} = 0$
   (C) $\left(x^2 - y^2\right)\frac{dy}{dx} - 2xy = 0$
   (D) $\left(x^2 + y^2\right)\frac{dy}{dx} + 2xy = 0$

4. If $A = \begin{bmatrix} 1 & 1 & 0 \\ 2 & 1 & 5 \end{bmatrix}$, then
   $a_{11}A_{21} + a_{12}A_{22} + a_{13}A_{23} =$
   (A) 1 (B) 0 (C) -1 (D) 2

5. If Rolle’s theorem for $f(x) = e^x (\sin x - \cos x)$ is verified on $\left[\frac{\pi}{4}, \frac{3\pi}{4}\right]$, then the value of $c$ is
   (A) $\frac{\pi}{3}$ (B) $\frac{\pi}{2}$ (C) $\frac{3\pi}{4}$ (D) $\pi$

6. The joint equation of lines passing through the origin and trisecting the first quadrant is
   (A) $x^2 + \sqrt{3}xy - y^2 = 0$
   (B) $x^2 - \sqrt{3}xy - y^2 = 0$
   (C) $\sqrt{3}x^2 - 4xy + \sqrt{3}y^2 = 0$
   (D) $3x^2 - y^2 = 0$

7. If $2 \tan^{-1} (\cos x) = \tan^{-1} (2 \cosec x)$ then $\sin x + \cos x =$
   (A) $2\sqrt{2}$ (B) $\sqrt{2}$
   (C) $\frac{1}{\sqrt{2}}$ (D) $\frac{1}{2}$

8. Direction cosines of the line $\frac{x+2}{2} = \frac{2y-5}{3}$, $z = -1$ are
   (A) $\frac{4}{5}, \frac{3}{5}, 0$ (B) $\frac{3}{5}, \frac{4}{5}, \frac{1}{5}$
   (C) $\frac{-3}{5}, \frac{4}{5}, 0$ (D) $\frac{4}{5}, \frac{-2}{5}, \frac{1}{5}$

9. $\int \frac{1}{\sqrt{8+2x-x^2}} \, dx =$
   (A) $\frac{1}{3} \sin^{-1}\left(\frac{x-1}{3}\right) + c$
   (B) $\sin^{-1}\left(\frac{x+1}{3}\right) + c$
   (C) $\frac{1}{3} \sin^{-1}\left(\frac{x+1}{3}\right) + c$
   (D) $\sin^{-1}\left(\frac{x-1}{3}\right) + c$

10. The approximate value of $f(x) = x^3 + 5x^2 - 7x + 9$ at $x = 1.1$ is
    (A) 8.6 (B) 8.5 (C) 8.4 (D) 8.3

11. If r. v. $X$: waiting time in minutes for bus and p.d.f. of $X$ is given by
    $f(x) = \begin{cases} 1, & 0 \leq x \leq 5 \\ 0, & otherwise \end{cases}$
    then probability of waiting time not more than 4 minutes is =
    (A) 0.3 (B) 0.8 (C) 0.2 (D) 0.5

12. In $\Delta ABC \left(a - b\right)^2 \cos^2 \frac{C}{2} + \left(a + b\right)^2 \sin^2 \frac{C}{2} =$
    (A) $b^2$ (B) $c^2$
    (C) $a^2$ (D) $a^2 + b^2 + c^2$

13. Derivative of $\log (\sec \theta + \tan \theta)$ with respect to $\sec \theta$ at $\theta = \frac{\pi}{4}$ is
    (A) 0 (B) 1 (C) $\frac{1}{\sqrt{2}}$ (D) $\sqrt{2}$
14. The joint equation of bisectors of angles between lines \( x = 5 \) and \( y = 3 \) is \[ \text{(A) } (x - 5)(y - 3) = 0 \] \[ \text{(B) } x^2 - y^2 - 10x + 6y + 16 = 0 \] \[ \text{(C) } xy = 0 \] \[ \text{(D) } xy - 5x - 3y + 15 = 0 \]

15. The point on the curve \( 6y = x^3 + 2 \) at which \( y \) - co-ordinate is changing 8 times as fast as \( x \) - co-ordinate is \[ \text{(A) } (4, 11) \] \[ \text{(B) } (4, -11) \] \[ \text{(C) } (-4, 11) \] \[ \text{(D) } (-4, -11) \]

16. If the function \( f(x) \) defined by \[ f(x) = x \sin \frac{1}{x} \], for \( x \neq 0 \] \[ = k \], for \( x = 0 \] is continuous at \( x = 0 \), then \( k = \) \[ \text{(A) 0} \] \[ \text{(B) 1} \] \[ \text{(C) -1} \] \[ \text{(D) } \frac{1}{2} \]

17. If \( y = e^{m \sin^{-1} x} \) and \( (1-x^2) \left( \frac{dy}{dx} \right)^2 = Ay^2 \), then \( A = \) \[ \text{(A) } m \] \[ \text{(B) } -m \] \[ \text{(C) } m^2 \] \[ \text{(D) } -m^2 \]

18. \[ \int \left( \frac{4e^x - 25}{2e^x - 5} \right) dx = Ax + B \log |2e^x - 5| + c, \] then \[ \text{(A) } A = 5, B = 3 \] \[ \text{(B) } A = 5, B = -3 \] \[ \text{(C) } A = -5, B = 3 \] \[ \text{(D) } A = -5, B = -3 \]

19. \[ \frac{\tan^{-1}(\sqrt{3}) - \sec^{-1}(-2)}{\cos^{-1}(-\sqrt{2}) + \cos^{-1}\left(-\frac{1}{2}\right)} = \] \[ \text{(A) } \frac{4}{5} \] \[ \text{(B) } -\frac{4}{5} \] \[ \text{(C) } \frac{3}{5} \] \[ \text{(D) } 0 \]

20. For what value of \( k \), the function defined by \[ f(x) = \frac{\log(1+2x) \sin x^2}{x^2}, \] for \( x \neq 0 \] \[ = k \], for \( x = 0 \] is continuous at \( x = 0 \)? \[ \text{(A) } 2 \] \[ \text{(B) } \frac{1}{2} \] \[ \text{(C) } \frac{\pi}{90} \] \[ \text{(D) } \frac{90}{\pi} \]

21. If \( \log_{10} \left( \frac{x^2 - y^2}{x^2 + y^2} \right) = 2 \), then \( \frac{dy}{dx} = \) \[ \text{(A) } \frac{-99x}{101y} \] \[ \text{(B) } \frac{99x}{101y} \] \[ \text{(C) } -\frac{99y}{101x} \] \[ \text{(D) } \frac{99y}{101x} \]

22. \[ \int \frac{2 - \sin x}{2 + \sin x} dx = \] \[ \text{(A) } 1 \] \[ \text{(B) } 3 \] \[ \text{(C) } 2 \] \[ \text{(D) } 0 \]

23. \[ \int \left( \frac{x^2 + 2}{x + \tan^{-1} x} \right) dx = \] \[ \text{(A) } \log a.a^{x \tan^{-1} x} + c \] \[ \text{(B) } \frac{(x + \tan^{-1} x)}{\log a} + c \] \[ \text{(C) } a^{x \tan^{-1} x} + c \] \[ \text{(D) } \log a.(x + \tan^{-1} x) + c \]

24. The degree and order of the differential equation \[ 1 + \left( \frac{dy}{dx} \right)^{rac{7}{2}} = 7 \left( \frac{d^2 y}{dx^2} \right) \] respectively are \[ \text{(A) } 3 \text{ and } 7 \] \[ \text{(B) } 3 \text{ and } 2 \] \[ \text{(C) } 7 \text{ and } 3 \] \[ \text{(D) } 2 \text{ and } 3 \]

25. The acute angle between the line \( \bar{r} = (\hat{i} + 2\hat{j} + \hat{k}) + \lambda(\hat{i} + \hat{j} + \hat{k}) \) and the plane \( (2\hat{i} - \hat{j} + \hat{k}) = 5 \) \[ \text{(A) } \cos^{-1} \left( \frac{\sqrt{2}}{3} \right) \] \[ \text{(B) } \sin^{-1} \left( \frac{5}{\sqrt{3}} \right) \] \[ \text{(C) } \tan^{-1} \left( \frac{\sqrt{2}}{3} \right) \] \[ \text{(D) } \sin^{-1} \left( \frac{\sqrt{2}}{\sqrt{3}} \right) \]

26. The area of the region bounded by the curve \( y = 2x - x^2 \) and \( X \) - axis is \[ \text{(A) } \frac{2}{3} \text{ sq.units} \] \[ \text{(B) } \frac{4}{3} \text{ sq.units} \] \[ \text{(C) } \frac{5}{3} \text{ sq.units} \] \[ \text{(D) } \frac{8}{3} \text{ sq.units} \]
27. If \[ \int \frac{f(x)}{\log(x)} \, dx = \log(\log x) + c , \text{ then } f(x)= \]
(A) \( \cot x \)  
(B) \( \tan x \)  
(C) \( \sec x \)  
(D) \( \cosec x \)

28. If A and B are foot of perpendicular drawn from point Q (a, b, c) to the planes \( yz \) and \( zx \), then equation of plane through the points A, B and O is _______.

(A) \( x + y + z = 0 \)  
(B) \( x - y - z = 0 \)  
(C) \( x - y - z = 0 \)  
(D) \( x + y + z = 0 \)

29. If \( \hat{a} = \hat{i} + \hat{j} + 2\hat{k} \), \( \hat{b} = 2\hat{i} - \hat{j} + \hat{k} \) and \( \hat{c} = 3\hat{i} - \hat{k} \) and \( \hat{a} = ma + nb \) then \( m + n = \) _______.

(A) 0  
(B) 1  
(C) 2  
(D) -1

30. \[ \int_0^\pi \frac{2 \sec x}{\sqrt{\sec x + \sqrt{\csc x}}} \, dx = \]
(A) \( \frac{\pi}{2} \)  
(B) \( \frac{\pi}{3} \)  
(C) \( \frac{\pi}{4} \)  
(D) \( \frac{\pi}{6} \)

31. If the p.d.f. of a r.v. X is given as

<table>
<thead>
<tr>
<th>( x_i )</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(X = z_i)</td>
<td>0.2</td>
<td>0.3</td>
<td>0.15</td>
<td>0.25</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Then F(0) =

(A) \( P(X < 0) \)  
(B) \( P(X > 0) \)  
(C) \( 1 - P(X > 0) \)  
(D) \( 1 - P(X < 0) \)

32. The particular solution of the differential equation \( y(1 + \log x) \frac{dx}{dy} - x \log x = 0 \) when \( x = e, y = e^2 \) is

(A) \( y = \log x \)  
(B) \( y = x \log x \)  
(C) \( x \log x = e \log x \)  
(D) \( y \log x = e \log x \)

33. M and N are the midpoints of the diagonals AC and BD respectively of quadrilateral ABCD, then \( \frac{AB + AD + CB + CD}{4} = \)

(A) \( 2 MN \)  
(B) \( 2 NM \)  
(C) \( 4 MN \)  
(D) \( 4 NM \)

34. If \( \sin x \) is the integrating factor (I. F.) of the linear differential equation \( \frac{dy}{dx} + Py = Q \), then P is

(A) \( \text{log } \sin x \)  
(B) \( \cos x \)  
(C) \( \tan x \)  
(D) \( \text{cot } x \)

35. Which of the following equation does not represent a pair of lines?

(A) \( x^2 - x = 0 \)  
(B) \( xy - x = 0 \)  
(C) \( x^2 - x + 1 = 0 \)  
(D) \( xy + x + y + 1 = 0 \)

36. Probability of guessing correctly atleast 7 out of 10 answers in a “True” or “False” test is =

(A) \( \frac{11}{64} \)  
(B) \( \frac{11}{32} \)  
(C) \( \frac{11}{16} \)  
(D) \( \frac{27}{32} \)

37. Principal solutions of the equation \( \sin 2x + \cos 2x = 0 \), where \( \pi < x < 2\pi \) are

(A) \( \frac{7\pi}{8}, \frac{11\pi}{8} \)  
(B) \( \frac{9\pi}{8}, \frac{13\pi}{8} \)  
(C) \( \frac{11\pi}{8}, \frac{15\pi}{8} \)  
(D) \( \frac{15\pi}{8}, \frac{19\pi}{8} \)

38. If line joining point A and B having position vectors \( 6\hat{a} - 4\hat{b} + 4\hat{c} \) and \( -\hat{4c} \) respectively, and the line joining the points C and D having position vectors \( -\hat{a} - 2\hat{b} - 3\hat{c} \) and \( \hat{a} + 2\hat{b} - 5\hat{c} \) intersect, then their point of intersection is

(A) B  
(B) C  
(C) D  
(D) A

39. If \( A = \begin{bmatrix} 2 & 2 \\ -3 & 2 \end{bmatrix} \), \( B = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \) then

\( (B^{-1} A^{-1})^{-1} = \)

(A) \( \begin{bmatrix} 2 & -2 \\ 2 & 3 \end{bmatrix} \)  
(B) \( \begin{bmatrix} 2 & 2 \\ -2 & 3 \end{bmatrix} \)  
(C) \( \begin{bmatrix} 2 & -3 \\ 2 & 2 \end{bmatrix} \)  
(D) \( \begin{bmatrix} 1 & -1 \\ 2 & 3 \end{bmatrix} \)

40. If \( p : \text{Every square is a rectangle} \)

\( q : \text{Every rhombus is a kite} \) then truth values of \( p \iff q \) are _______ and _______ respectively.

(A) F, F  
(B) T, F  
(C) F, T  
(D) T, T
41. If \( G(g), H(h) \) and \( P(p) \) are centroid, orthocenter and circumcenter of a triangle and \( x\hat{p} + y\hat{h} + z\hat{g} = 0 \) then \((x, y, z) = \)
   (A) 1, 1, \(-2\)       (B) 2, 1, \(-3\)
   (C) 1, 3, \(-4\)       (D) 2, 3, \(-5\)

42. Which of the following quantified statement is true?
   (A) The square of every real number is positive
   (B) There exists a real number whose square is negative
   (C) There exists a real number whose square is not positive
   (D) Every real number is rational

43. The general solution of the equation \( \tan^2 x = 1 \)
   is
   (A) \( n\pi + \frac{\pi}{4} \)       (B) \( n\pi - \frac{\pi}{4} \)
   (C) \( n\pi \pm \frac{\pi}{4} \)     (D) \( 2n\pi \pm \frac{\pi}{4} \)

44. The shaded part of given figure indicates the feasible region
   then the constraints are
   (A) \( x, y \geq 0, x + y \geq 0, x \geq 5, y \leq 3 \)
   (B) \( x, y \geq 0, x - y \geq 0, x \leq 5, y \leq 3 \)
   (C) \( x, y \geq 0, x - y \geq 0, x \leq 5, y \geq 3 \)
   (D) \( x, y \geq 0, x - y \leq 0, x \leq 5, y \leq 3 \)

45. Direction ratios of the line which is perpendicular to the lines with direction ratios \(-1, 2, 0\) and \(0, 2, 1\) are
   (A) 1, 1, 2       (B) 2, \(-1, 2\)
   (C) \(-2, 1, 2\)     (D) 2, 1, \(-2\)

46. If Matrix \( A = \begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix} \) such that \( Ax = I \), then \( x = \)
   (A) \( \begin{bmatrix} 1 & 3 \\ 5 & -1 \end{bmatrix} \)
   (B) \( \begin{bmatrix} 4 & 2 \\ 5 & -1 \end{bmatrix} \)
   (C) \( \begin{bmatrix} -3 & 2 \\ 5 & 4 \end{bmatrix} \)
   (D) \( \begin{bmatrix} 1 & -2 \\ 5 & -1 \end{bmatrix} \)

47. If \( \vec{a} = \hat{i} + \hat{j} + \hat{k}, \vec{b} = 2\hat{i} + \lambda\hat{j} + \hat{k}, \vec{c} = \hat{i} - \hat{j} + 4\hat{k} \)
and \( \vec{a} \cdot (\vec{b} \times \vec{c}) = 10 \), then \( \lambda \) is equal to
   (A) 6       (B) 7
   (C) 9       (D) 10

48. If r.v. \( X \sim B \left( n = 5, P = \frac{1}{3} \right) \) then \( P(2 < X < 4) = \)
   (A) \( \frac{80}{243} \)
   (B) \( \frac{40}{243} \)
   (C) \( \frac{40}{343} \)
   (D) \( \frac{80}{343} \)

49. The objective function \( z = x_1 + x_2 \), subject to \( x_1 + x_2 \leq 10, -2x_1 + 3x_2 \leq 15, x_1 \leq 6, x_1, x_2 \geq 0 \)
has maximum value _______ of the feasible region.
   (A) at only one point
   (B) at only two points
   (C) at every point of the segment joining two points
   (D) at every point of the line joining two points

50. Symbolic form of the given switching circuit is equivalent to ________
   (A) \( p \lor \sim q \)
   (B) \( p \land \sim q \)
   (C) \( p \leftrightarrow q \)
   (D) \( \sim(p \leftrightarrow q) \)

Answer Key

1. (B) 2. (D) 3. (B) 4. (B)
5. (D) 6. (C) 7. (B) 8. (A)
9. (D) 10. (A) 11. (B) 12. (B)
13. (B) 14. (B) 15. (A) 16. (A)
17. (C) 18. (B) 19. (B) 20. (C)
21. (A) 22. (D) 23. (C) 24. (B)
25. (B) 26. (B) 27. (A) 28. (A)
29. (C) 30. (C) 31. (C) 32. (A)
33. (C) 34. (D) 35. (C) 36. (A)
37. (C) 38. (A) 39. (A) 40. (D)
41. (B) 42. (C) 43. (C) 44. (B)
45. (B) 46. (C) 47. (A) 48. (B)
49. (C) 50. (D)