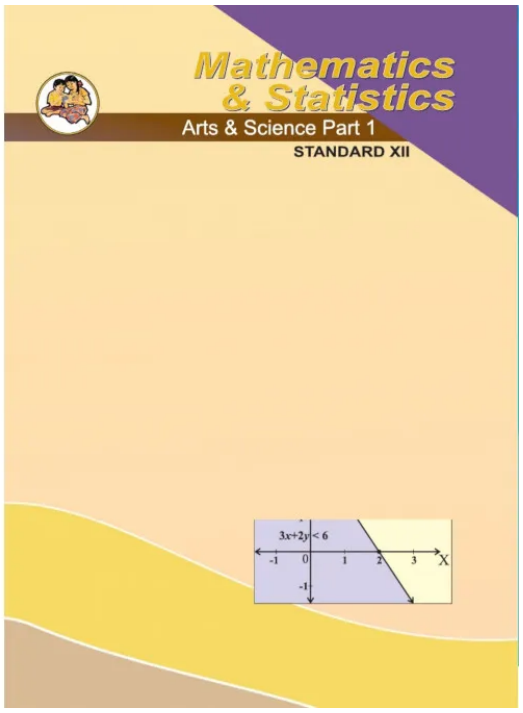
Maharashtra Board Solutions Class 12-Arts & Science Maths (Part 1): Chapter 1- Mathematical Logic

Class 12 - Chapter 1 Mathematical Logic



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Maharashtra Board Solutions Class 12-Arts & Science Maths (Part 1): Chapter 1- Mathematical Logic

Class 12: Maths Chapter 1 solutions. Complete Class 12 Maths Chapter 1 Notes.

Maharashtra Board Solutions Class 12-Arts & Science Maths (Part 1): Chapter 1- Mathematical Logic

Maharashtra Board 12th Maths Chapter 1, Class 12 Maths Chapter 1 solutions

Ex 1.1

Question 1.

State which of the following sentences are statements. Justify your answer. In case of statement, write down the truth value :

(i) 5 + 4 = 13.

Solution:

It is a statement which is false, hence its truth value is 'F'.

(ii) x – 3 = 14.

Solution:

It is an open sentence, hence it is not a statement.

(iii) Close the door.

Solution:

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It is an imperative sentence, hence it is not a statement.

(iv) Zero is a complex number.

Solution:

It is a statement which is true, hence its truth value is ‘T’.

(v) Please get me breakfast.

Solution:

It is an imperative sentence, hence it is not a statement.

(vi) Congruent triangles are also similar.

Solution:

It is a statement which is true, hence its truth value is ‘T’.

(vii) $x^2 = x$.

Solution:

It is an open sentence, hence it is not a statement,

(viii) A quadratic equation cannot have more than two roots.

Solution:

It is a statement which is true, hence its truth value is ‘T’.

(ix) Do you like Mathematics ?

Solution:

It is an interrogative sentence, hence it is not a statement.

(x) The sun sets in the west.

Solution:

It is a statement which is true, hence its truth value is ‘T’.

(xi) All real numbers are whole numbers.

Solution:

It is a statement which is false, hence its truth value is ‘F’.

(xii) Can you speak in Marathi ?

Solution:

It is an interrogative sentence, hence it is not a statement.

(xiii) $x^2 – 6x – 7 = 0$, when $x = 7$.

Solution:

It is a statement which is true, hence its truth value is ‘T’.

(xiv) The sum of cuberoots of unity is zero.

Solution:

It is a statement which is true, hence its truth value is ‘T’.

(xv) It rains heavily.

Solution :

It is an open sentence, hence it is not a statement.

Question 2.

Write the following compound statements symbolically:

(i) Nagpur is in Maharashtra and Chennai is in Tamil Nadu.

Solution:

Let p : Nagpur is in Maharashtra.

q : Chennai is in Tamil Nadu.

Then the symbolic form of the given statement is $P \wedge q$.

(ii) Triangle is equilateral or isosceles,

Solution:

Let p : Triangle is equilateral.

q : Triangle is isosceles.

Then the symbolic form of the given statement is $P \vee q$.

(iii) The angle is right angle if and only if it is of measure 90°.

Solution:

Let p : The angle is right angle.

q : It is of measure 90°.

Then the symbolic form of the given statement is $p \leftrightarrow q$

(iv) Angle is neither acute nor obtuse.

Solution:

Let p : Angle is acute.

q : Angle is obtuse.

Then the symbolic form of the given statement is

$\sim p \wedge \sim q$.

(v) If Δ ABC is right angled at B, then m$\angle$A + m$\angle$C = 90°.

Solution:

Let p : Δ ABC is right angled at B.

q : m∠A + m∠C = 90°.

Then the symbolic form of the given statement is p → q

(vi) Hima Das wins gold medal if and only if she runs fast.

Solution:

Let p : Hima Das wins gold medal

q : She runs fast.

Then the symbolic form of the given statement is p ↔ q.

(vii) x is not irrational number but it is a square of an integer.

Solution:

Let p : x is not irrational number

q : It is a square of an integer

Then the symbolic form of the given statement is p ∧ q

Note : If p : x is irrational number, then the symbolic form of the given statement is ~p ∧ q.

Question 3.

Write the truth values of the following :

(i) 4 is odd or 1 is prime.

Solution:

Let p : 4 is odd.

q : 1 is prime.

Then the symbolic form of the given statement is p ∨ q.

The truth values of both p and q are F.

∴ the truth value of p v q is F. … [F ∨ F = F]

(ii) 64 is a perfect square and 46 is a prime number.

Solution:

Let p : 64 is a perfect square.

q : 46 is a prime number.

Then the symbolic form of the given statement is p∧q.

The truth values of p and q are T and F respectively.

∴ the truth value of p ∧ q is F. … [T ∧ F ≡ F]

(iii) 5 is a prime number and 7 divides 94.

Solution:

Let p : 5 is a prime number.

q : 7 divides 94.

Then the symbolic form of the given statement is p∧q.

The truth values of p and q are T and F respectively.

∴ the truth value of p ∧ q is F. … [T ∧ F ≡ F]

(iv) It is not true that 5 – 3i is a real number.

Solution:

Let p : 5 – 3i is a real number.

Then the symbolic form of the given statement is ~ p.

The truth values of p is F.

∴ the truth values of ~ p is T. … [~ F ≡ T]

(v) If 3 × 5 = 8, then 3 + 5 = 15.

Solution:

Let p : 3 × 5 = 8.

q : 3 + 5 = 15.

Then the symbolic form of the given statement is p → q.

The truth values of both p and q are F.

∴ the truth value of p → q is T. … [F → F ≡ T]

(vi) Milk is white if and only if sky is blue.

Solution:

Let p : Milk is white.

q : Sky is blue

Then the symbolic form of the given statement is p ↔ q.

The truth values of both p and q are T.

∴ the truth value of p ↔ q is T. … [T ↔ T ≡ T]

(vii) 24 is a composite number or 17 is a prime number.

Solution :

Let p : 24 is a composite number.

q : 17 is a prime number.

Then the symbolic form of the given statement is p ∨ q.

The truth values of both p and q are T.

∴ the truth value of p ∨ q is T. … [T ∨ T ≡ T]

Question 4.

If the statements p, q are true statements and r, s are false statements, then determine the truth values of the following:

(i) p ∨ (q ∧ r)

Solution:

Truth values of p and q are T and truth values of r and s are F.

p ∨ (q ∧ r) ≡ T ∨ (T ∧ F)

≡ T ∧ F ≡ T

Hence the truth value of the given statement is true.

(ii) (p → q) ∨ (r → s)

Solution:

(p → q) ∨ (r → s) ≡ (T → T) ∨ (F → F)

≡ T ∨ T ≡ T

Hence the truth value of the given statement is true.

(iii) (q ∧ r) ∨ (~p ∧ s)

Solution:

(q ∧ r) ∨ (~p ∧ s) ≡ (T ∧ F) ∨ (~T ∧ F)

≡ F ∨ (F ∧ F)

≡ F ∨ F ≡ F

Hence the truth value of the given statement is false.

(iv) (p → q) ∧ (~ r)

Solution:

(p → q) ∧ (~ r) ≡ (T → T) ∧ (~ F)

≡ T ∧ T ≡ T

Hence the truth value of the given statement is true.

(v) (~r ↔ p) → (~q)

Solution:

(~r ↔ p) → (~q) ≡ (~F ↔ T) → (~T)

≡ (T ↔ T) → F

≡ T → F ≡ F

Hence the truth value of the given statement is false.

(vi) [~p ∧ (~q ∧ r) ∨ (q ∧ r) ∨ (p ∧ r)]

Solution:

[~p ∧ (~q ∧ r) ∨ (q ∧ r) ∨ (p ∧ r)]

≡ [~T ∧ (~T ∧ F)] ∨ [(T ∧ F) ∨ (T ∧ F)]

≡ [F ∧ (F ∧ F)] ∨ [F ∨ F]

≡ (F ∧ F) ∨ F

≡ F ∨ F ≡ F

Hence the truth value of the given statement is false.

(vii) [(~ p ∧ q) ∧ (~ r)] ∨ [(q → p) → (~ s ∨ r)]

Solution:

$[(\sim p \wedge q) \wedge (\sim r)] \vee [(q \rightarrow p) \rightarrow (\sim s \vee r)]$

$\equiv [(\sim T \wedge T) \wedge (\sim F)] \vee [(T \rightarrow T) \rightarrow (\sim F \vee F)]$

$\equiv [(F \wedge T) \wedge T] \vee [T \rightarrow (T \vee F)]$

$\equiv (F \wedge T) \vee (T \rightarrow T)$

$\equiv F \vee T \equiv T$

Hence the truth value of the given statement is true.

(viii) $\sim [(\sim p \wedge r) \vee (s \rightarrow \sim q)] \leftrightarrow (p \wedge r)$

Solution :

$\sim [(\sim p \wedge r) \vee (s \rightarrow \sim q)] \leftrightarrow (p \wedge r)$

$\equiv \sim [(\sim T \wedge F) \vee (F \rightarrow \sim T)] \leftrightarrow (T \wedge F)$

$\equiv \sim [(F \wedge F) \vee (F \rightarrow F)] \leftrightarrow F$

$\equiv \sim (F \vee T) \leftrightarrow F$

$\equiv \sim T \leftrightarrow F$

$\equiv F \leftrightarrow F \equiv T$

Hence the truth value of the given statement is true.

Question 5.

Write the negations of the following :

(i) Tirupati is in Andhra Pradesh.

Solution:

The negations of the given statements are :

Tirupati is not in Andhra Pradesh.

(ii) 3 is not a root of the equation $x^2 + 3x – 18 = 0$.

Solution:

3 is a root of the equation $x^2 + 3x – 18 = 0$.

(iii) 2–√ is a rational number.

Solution:

2–√ is not a rational number.

(iv) Polygon ABCDE is a pentagon.

Solution:

Polygon ABCDE is not a pentagon.

(v) 7 + 3 > 5.

Solution :

7 + 3 > 5.

Ex 1.2

Question 1.

Construct the truth table for each of the following statement patterns:

(i) [(p → q) ∧ q] → p

Solution :

Here are two statements and three connectives.

∴ there are 2 × 2 = 4 rows and 2 + 3 = 5 columns in the truth table.

p	q	$p \to q$	$(p \to q) \wedge q$	$[(p \to q) \wedge q] \to p$
T	T	T	T	T
T	F	F	F	T
F	T	T	T	F
F	F	T	F	T

(ii) (p ∧ ~q) ↔ (p → q)

Solution:

p	q	$\sim q$	$p \wedge \sim q$	$p \to q$	$(p \wedge \sim q) \leftrightarrow (p \to q)$
T	T	F	F	T	F
T	F	T	T	F	F
F	T	F	F	T	F
F	F	T	F	T	F

(iii) (p ∧ q) ↔ (q ∨ r)

Solution:

p	q	r	$p \wedge q$	$q \vee r$	$(p \wedge q) \leftrightarrow (q \vee r)$
T	T	T	T	T	T
T	T	F	T	T	T
T	F	T	F	T	F
T	F	F	F	F	T
F	T	T	F	T	F
F	T	F	F	T	F
F	F	T	F	T	F
F	F	F	F	F	T

(iv) p → [~(q ∧ r)]

Solution:

p	q	r	$q \wedge r$	$\sim (q \wedge r)$	$p \rightarrow [\sim (q \wedge r)]$
T	T	T	T	F	F
T	T	F	F	T	T
T	F	T	F	T	T
T	F	F	F	T	T
F	T	T	T	F	T
F	T	F	F	T	T
F	F	T	F	T	T
F	F	F	F	T	T

(v) ~p ∧ [(p ∨ ~q) ∧ q]

Solution:

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p	q	$\sim p$	$\sim q$	$p \vee \sim q$	$(p \vee \sim q) \wedge q$	$\sim p \wedge [(p \vee \sim q) \wedge q]$
T	T	F	F	T	T	F
T	F	F	T	T	F	F
F	T	T	F	F	F	F
F	F	T	T	T	F	F

(vi) (~p → ~q) ∧ (~q → ~p)

Solution:

p	q	$\sim p$	$\sim q$	$\sim p \rightarrow \sim q$	$\sim q \rightarrow \sim p$	$(\sim p \rightarrow \sim q) \wedge (\sim q \rightarrow \sim p)$
T	T	F	F	T	T	T
T	F	F	T	T	F	F
F	T	T	F	F	T	F
F	F	T	T	T	T	T

(vii) (q → p) ∨ (~p ↔ q)

Solution:

p	q	$\sim p$	$q \rightarrow p$	$\sim p \leftrightarrow q$	$(q \rightarrow p) \vee (\sim p \leftrightarrow q)$
T	T	F	T	F	T
T	F	F	T	T	T
F	T	T	F	T	T
F	F	T	T	F	T

(viii) [p → (q → r)] ↔ [(p ∧ q) → r]

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Solution:

p	q	r	$q \rightarrow r$	$p \rightarrow (q \rightarrow r)$	$p \wedge q$	$(p \wedge q) \rightarrow r$	$[p \rightarrow (q \rightarrow r)] \leftrightarrow [(p \wedge q) \rightarrow r]$
T	T	T	T	T	T	T	T
T	T	F	F	F	T	F	T
T	F	T	T	T	F	T	T
T	F	F	T	T	F	T	T
F	T	T	T	T	F	T	T
F	T	F	F	T	F	T	T
F	F	T	T	T	F	T	T
F	F	F	T	T	F	T	T

(ix) p → [~(q ∧ r)]

Solution:

p	q	r	$q \wedge r$	$\sim (q \wedge r)$	$p \rightarrow [\sim (q \wedge r)]$
T	T	T	T	F	F
T	T	F	F	T	T
T	F	T	F	T	T
T	F	F	F	T	T
F	T	T	T	F	T
F	T	F	F	T	T
F	F	T	F	T	T
F	F	F	F	T	T

(x) (p ∨ ~q) → (r ∧ p)

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Solution:

p	q	r	$\sim q$	$p \vee \sim q$	$r \wedge p$	$(p \vee \sim q) \rightarrow (r \wedge p)$
T	T	T	F	T	T	T
T	T	F	F	T	F	F
T	F	T	T	T	T	T
T	F	F	T	T	F	F
F	T	T	F	F	F	T
F	T	F	F	F	F	T
F	F	T	T	T	F	F
F	F	F	T	T	F	F

Question 2.

Using truth tables prove the following logical equivalences.

(i) ~p ∧ q ≡ (p ∨ q) ∧ ~p

Solution:

1	2	3	4	5	6
p	q	$\sim p$	$\sim p \wedge q$	$p \vee q$	$(p \vee q) \wedge \sim p$
T	T	F	F	T	F
T	F	F	F	T	F
F	T	T	T	T	T
F	F	T	F	F	F

The entries in the columns 4 and 6 are identical.

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∴ ~p ∧ q ≡ (p ∨ q) ∧ ~p.

(ii) ~(p ∨ q) ∨ (~p ∧ q) ≡ ~p

Solution:

1	2	3	4	5	6	7
p	q	$\sim p$	$p \vee q$	$\sim(p \vee q)$	$\sim p \wedge q$	$\sim(p \vee q) \vee (\sim p \wedge q)$
T	T	F	T	F	F	F
T	F	F	T	F	F	F
F	T	T	T	F	T	T
F	F	T	F	T	F	T

The entries in the columns 3 and 7 are identical.

∴ ~(p ∨ q) ∧ (~p ∧ q) = ~p.

(iii) p ↔ q ≡ ~[(p ∨ q) ∧ ~(p ∧ q)]

Solution:

1	2	3	4	5	6	7	8
p	q	$p \leftrightarrow q$	$p \vee q$	$p \wedge q$	$\sim(p \wedge q)$	$(p \vee q) \wedge \sim(p \wedge q)$	$\sim[(p \vee q) \wedge \sim(p \wedge q)]$
T	T	T	T	T	F	F	T
T	F	F	T	F	T	T	F
F	T	F	T	F	T	T	F
F	F	T	F	F	T	F	T

The entries in the columns 3 and 8 are identical.

∴ p ↔ q ≡ ~[(p ∨ q) ∧ ~(p ∧ q)].

(iv) p → (q → p) ≡ ~p → (p → q)

Solution:

1	2	3	4	5	6	7
p	q	$q \to p$	$p \to (q \to p)$	$\sim p$	$p \to q$	$\sim p \to (p \to q)$
T	T	T	T	F	T	T
T	F	T	T	F	F	T
F	T	F	T	T	T	T
F	F	T	T	T	T	T

The entries in the columns 4 and 7 are identical.

∴ p → (q → p) ≡ ~p → (p → q).

(v) (p ∨ q) → r ≡ (p → r) ∧ (q → r)

Solution:

1	2	3	4	5	6	7	8
p	q	r	$p \vee q$	$(p \vee q) \rightarrow r$	$p \rightarrow r$	$q \rightarrow r$	$(p \rightarrow r) \wedge (q \rightarrow r)$
T	T	T	T	T	T	T	T
T	T	F	T	F	F	F	F
T	F	T	T	T	T	T	T
T	F	F	T	F	F	T	F
F	T	T	T	T	T	T	T
F	T	F	T	F	T	F	F
F	F	T	F	T	T	T	T
F	F	F	F	T	T	T	T

The entries in the columns 5 and 8 are identical.

∴ (p ∨ q) → r ≡ (p → r) ∧ (q → r).

(vi) p → (q ∧ r) ≡ (p → q) ∧ (p → r)

Solution:

1	2	3	4	5	6	7	8
p	q	r	$q \wedge r$	$p \rightarrow (q \wedge r)$	$p \rightarrow q$	$p \rightarrow r$	$(p \rightarrow q) \wedge (p \rightarrow r)$
T	T	T	T	T	T	T	T
T	T	F	F	F	T	F	F
T	F	T	F	F	F	T	F
T	F	F	F	F	F	F	F
F	T	T	T	T	T	T	T
F	T	F	F	T	T	T	T
F	F	T	F	T	T	T	T
F	F	F	F	T	T	T	T

The entries in the columns 5 and 8 are identical.

∴ p → (q ∧ r) ≡ (p → q) ∧ (p → r).

(vii) p ∧ (q ∨ r) ≡ (p ∧ q) ∨ (p ∧ r)

Solution:

1	2	3	4	5	6	7	8
p	q	r	$p \vee q$	$(p \vee q) \rightarrow r$	$p \rightarrow r$	$q \rightarrow r$	$(p \rightarrow r) \wedge (q \rightarrow r)$
T	T	T	T	T	T	T	T
T	T	F	T	F	F	F	F
T	F	T	T	T	T	T	T
T	F	F	T	F	F	T	F
F	T	T	T	T	T	T	T
F	T	F	T	F	T	F	F
F	F	T	F	T	T	T	T
F	F	F	F	T	T	T	T

The entries in the columns 5 and 8 are identical.

∴ p ∧ (q ∨ r) ≡ (p ∧ q) ∨ (p ∧ r).

(viii) [~(p ∨ q) ∨ (p ∨ q)] ∧ r ≡ r

Solution:

1	2	3	4	5	6	7
p	q	r	$p \vee q$	$\sim(p \vee q)$	$\sim(p \vee q) \vee (p \vee q)$	$[\sim(p \vee q) \vee (p \vee q)] \wedge r$
T	T	T	T	F	T	T
T	T	F	T	F	T	F
T	F	T	T	F	T	T
T	F	F	T	F	T	F
F	T	T	T	F	T	T
F	T	F	T	F	T	F
F	F	T	F	T	T	T
F	F	F	F	T	T	F

The entries in the columns 3 and 7 are identical.

∴ [~(p ∨ q) ∨ (p ∨ q)] ∧ r ≡ r.

(ix) ~(p ↔ q) ≡ (p ∧ ~q) ∨ (q ∧ ~p)

Solution:

1	2	3	4	5	6	7	8	9
p	q	$\sim p$	$\sim q$	$p \leftrightarrow q$	$\sim(p \leftrightarrow q)$	$p \wedge \sim q$	$q \wedge \sim p$	$(p \wedge \sim q) \vee (q \wedge \sim p)$
T	T	F	F	T	F	F	F	F
T	F	F	T	F	T	T	F	T
F	T	T	F	F	T	F	T	T
F	F	T	T	T	F	F	F	F

The entries in the columns 6 and 9 are identical.

∴ ~(p ↔ q) ≡ (p ∧ ~q) ∨ (q ∧ ~p).

Question 3.

Examine whether each of the following statement patterns is a tautology or a contradiction or a contingency.

(i) (p ∧ q) → (q ∨ p)

Solution:

p	q	$p \wedge q$	$q \vee p$	$(p \wedge q) \rightarrow (q \vee p)$
T	T	T	T	T
T	F	F	T	T
F	T	F	T	T
F	F	F	F	T

All the entries in the last column of the above truth table are T.

∴ (p ∧ q) → (q ∨ p) is a tautology.

(ii) (p → q) ↔ (~p ∨ q)

Solution:

p	q	$\sim p$	$p \rightarrow q$	$\sim p \vee q$	$(p \rightarrow q) \leftrightarrow (\sim p \vee q)$
T	T	F	T	T	T
T	F	F	F	F	T
F	T	T	T	T	T
F	F	T	T	T	T

All the entries in the last column of the above truth table are T.

∴ (p → q) ↔ (~p ∨ q) p is a tautology.

(iii) [~(~p ∧ ~q)] ∨ q

Solution:

p	q	$\sim p$	$\sim q$	$\sim p \wedge \sim q$	$\sim(\sim p \wedge \sim q)$	$[\sim(\sim p \wedge \sim q)] \vee q$
T	T	F	F	F	T	T
T	F	F	T	F	T	T
F	T	T	F	F	T	T
F	F	T	T	T	F	F

The entries in the last column of the above truth table are neither all T nor all F.

∴ [~(~p ∧ ~q)] ∨ q is a contingency.

(iv) [(p → q) ∧ q)] → p

Solution:

p	q	$p \rightarrow q$	$(p \rightarrow q) \wedge q$	$[(p \rightarrow q) \wedge q] \rightarrow p$
T	T	T	T	T
T	F	F	F	T
F	T	T	T	F
F	F	T	F	T

The entries in the last column of the above truth table are neither all T nor all F.

∴ [(p → q) ∧ q)] → p is a contingency

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(v) [(p → q) ∧ ~q] → ~p

Solution:

p	q	$\sim p$	$\sim q$	$p \to q$	$(p \to q) \wedge \sim q$	$[(p \to q) \wedge \sim q] \to \sim p$
T	T	F	F	T	F	T
T	F	F	T	F	F	T
F	T	T	F	T	F	T
F	F	T	T	T	T	T

All the entries in the last column of the above truth table are T.

∴ [(p → q) ∧ ~q] → ~p is a tautology.

(vi) (p ↔ q) ∧ (p → ~q)

Solution:

p	q	$\sim q$	$p \leftrightarrow q$	$p \to \sim q$	$(p \leftrightarrow q) \wedge (p \to \sim q)$
T	T	F	T	F	F
T	F	T	F	T	F
F	T	F	F	T	F
F	F	T	T	T	T

The entries in the last column of the above truth table are neither all T nor all F.

∴ (p ↔ q) ∧ (p → ~q) is a contingency.

(vii) ~(~q ∧ p) ∧ q

Solution:

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p	q	$\sim q$	$\sim q \wedge p$	$\sim(\sim q \wedge p)$	$\sim(\sim q \wedge p) \wedge q$
T	T	F	F	T	T
T	F	T	T	F	F
F	T	F	F	T	T
F	F	T	F	T	F

The entries in the last column of the above truth table are neither all T nor all F.

∴ ~(~q ∧ p) ∧ q is a contingency.

(viii) (p ∧ ~q) ↔ (p → q)

Solution:

p	q	$\sim q$	$p \wedge \sim q$	$p \rightarrow q$	$(p \wedge \sim q) \leftrightarrow (p \rightarrow q)$
T	T	F	F	T	F
T	F	T	T	F	F
F	T	F	F	T	F
F	F	T	F	T	F

All the entries in the last column of the above truth table are F.

∴ (p ∧ ~q) ↔ (p → q) is a contradiction.

(ix) (~p → q) ∧ (p ∧ r)

Solution:

p	q	r	$\sim p$	$\sim p \rightarrow q$	$p \wedge r$	$(\sim p \rightarrow q) \wedge (p \wedge r)$
T	T	T	F	T	T	T
T	T	F	F	T	F	F
T	F	T	F	T	T	T
T	F	F	F	T	F	F
F	T	T	T	T	F	F
F	T	F	T	T	F	F
F	F	T	T	F	F	F
F	F	F	T	F	F	F

The entries in the last column of the above truth table are neither all T nor all F.

∴ (~p → q) ∧ (p ∧ r) is a contingency.

(x) [p → (~q ∨ r)] ↔ ~[p → (q → r)]

Solution:

p	q	r	$\sim q$	$\sim q \vee r$	$p \rightarrow (\sim q \vee r)$	$q \rightarrow r$	$p \rightarrow (q \rightarrow r)$	$\sim [p \rightarrow (q \rightarrow r)]$	$[p \rightarrow (\sim q \vee r)] \leftrightarrow \sim [p \rightarrow (q \rightarrow r)]$
T	T	T	F	T	T	T	T	F	F
T	T	F	F	F	F	F	F	T	F
T	F	T	T	T	T	T	T	F	F
T	F	F	T	T	T	T	T	F	F
F	T	T	F	T	T	T	T	F	F
F	T	F	F	F	T	F	T	F	F
F	F	T	T	T	T	T	T	F	F
F	F	F	T	T	T	T	T	F	F

All the entries in the last column of the above truth table are F.

∴ [p → (~q ∨ r)] ↔ ~[p → (q → r)] is a contradiction

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Ex 1.3

Question 1.

If A = {3, 5, 7, 9, 11, 12}, determine the truth value of each of the following.

(i) ∃ x ∈ A such that x – 8 = 1

Solution:

Clearly x = 9 ∈ A satisfies x – 8 = 1. So the given statement is true, hence its truth value is T.

(ii) x ∈ A, x^2 + x is an even number

Solution:

For each x ∈ A, x^2 + x is an even number. So the given statement is true, hence its truth value is T.

(iii) ∃ x ∈ A such that x^2 < 0

Solution:

There is no x ∈ A which satisfies x^2 < 0. So the given statement is false, hence its truth value is F.

(iv) x ∈ A, x is an even number

Solution:

x = 3 ∈ A, x = 5 ∈ A, x = 7 ∈ A, x = 9 ∈ A, x = 11 ∈ A do not satisfy x is an even number. So the given statement is false, hence its truth value is F.

(v) ∃ x ∈ A such that 3x + 8 > 40

Solution:

Clearly x = 11 ∈ A and x = 12 ∈ A satisfies 3x + 8 > 40. So the given statement is true, hence its truth value is T.

(vi) $x \in A, 2x + 9 > 14$

Solution:

For each $x \in A$, $2x + 9 > 14$. So the given statement is true, hence its truth value is T.

Question 2.

Write the duals of each of the following.

(i) $p \vee (q \wedge r)$

Solution:

The duals of the given statement patterns are :

$p \wedge (q \vee r)$

(ii) $p \wedge (q \wedge r)$

Solution:

$p \vee (q \vee r)$

(iii) $(p \vee q) \wedge (r \vee s)$

Solution:

$(p \wedge q) \vee (r \wedge s)$

(iv) $p \wedge \sim q$

Solution:

$p \vee \sim q$

(v) $(\sim p \vee q) \wedge (\sim r \wedge s)$

Solution:

$(\sim p \wedge q) \vee (\sim r \vee s)$

(vi) ~p ∧ (~q ∧ (p ∨ q) ∧ ~r)

Solution:

~p ∨ (~q ∨ (p ∧ q) ∨ ~r)

(vii) [~(p ∨ q)] ∧ [p ∨ ~(q ∧ ~s)]

Solution:

[~(p ∧ q)] ∨ [p ∧ ~(q ∨ ~s)]

(viii) c ∨ {p ∧ (q ∨ r)}

Solution:

t ∧ {p ∧ (q Ar)}

(ix) ~p ∨ (q ∧ r) ∧ t

Solution:

~p ∧ (q ∨ r) ∨ c

(x) (p ∨ q) ∨ c

Solution:

(p ∧ q) ∧ t

Question 3.

Write the negations of the following.

(i) x + 8 > 11 or y – 3 = 6

Solution:

Let p : x + 8 > 11, q : y — 3 = 6.

Then the symbolic form of the given statement is p ∨ q.

Since ~(p ∨ q) ≡ ~p ∧ ~q, the negation of given statement is :

'x + 8 > 11 and y – 3 ≠ 6' OR

'x + 8 ≯ 11 and y – 3 ≠ 6'

(ii) 11 < 15 and 25 > 20

Solution:

Let p: 11 < 15, q : 25 > 20.

Then the symbolic form of the given statement is p ∧ q.

Since ~(p ∧ q) ≡ ~p ∨ ~q, the negation of given statement is :

'11 ≮ 15 or 25 > 20.' OR

'11 ≯ 15 or 25 ≮ 20.'

(iii) Qudrilateral is a square if and only if it is a rhombus.

Solution:

Let p : Quadrilateral is a square.

q : It is a rhombus.

Then the symbolic form of the given statement is p ↔ q.

Since ~(p ↔ q) ≡ (p ∧ ~q) ∨ (q ∧ ~p), the negation of given statement is :

' Quadrilateral is a square but it is not a rhombus or quadrilateral is a rhombus but it is not a square.'

(iv) It is cold and raining.

Solution:

Let p : It is cold.

q : It is raining.

Then the symbolic form of the given statement is $p \wedge q$.

Since $\sim(p \wedge q) \equiv \sim p \vee \sim q$, the negation of the given statement is :

'It is not cold or not raining.'

(v) If it is raining then we will go and play football.

Solution:

Let p : It is raining.

q : We will go.

r : We play football.

Then the symbolic form of the given statement is $p \rightarrow (q \wedge r)$.

Since $\sim[p \rightarrow (q \wedge r)] \equiv p \wedge \sim(q \wedge r) \equiv p \wedge (q \vee \sim r)$, the negation of the given statement is :

'It is raining and we will not go or not play football.'

(vi) $2-\sqrt{}$ is a rational number.

Solution:

Let p : $2-\sqrt{}$ is a rational number.

The negation of the given statement is

' ~p : $2-\sqrt{}$ is not a rational number.'

(vii) All natural numbers are whole numers.

Solution:

The negation of the given statement is :

'Some natural numbers are not whole numbers.'

(viii) $n \in N, n^2 + n + 2$ is divisible by 4.

Solution:

The negation of the given statement is :

'$\exists\ n \in N$, such that $n^2 + n + 2$ is not divisible by 4.'

(ix) $\exists\ x \in N$ such that $x - 17 < 20$

Solution:

The negation of the given statement is :

' $x \in N, x - 17 \not< 20$.'

Question 4.

Write converse, inverse and contrapositive of the following statements.

(i) If $x < y$ then $x^2 < y^2$ $(x, y \in R)$

Solution:

Let p : $x < y$, q : $x^2 < y^2$.

Then the symbolic form of the given statement is $p \rightarrow q$.

Converse : $q \rightarrow p$ is the converse of $p \rightarrow q$.

i.e. If $x^2 < y^2$, then $x < y$.

Inverse : $\sim p \rightarrow \sim q$ is the inverse of $p \rightarrow q$.

i.e. If $x \not< y$, then $x^2 \not< y^2$. OR

If $x \not< y$, then $x^2 \not< y^2$.

Contrapositive : $\sim q \rightarrow p$ is the contrapositive of

$p \rightarrow q$ i.e. If $x^2 \not> y^2$, then $x \not> y$. OR

If $x^2 \not< y^2$, then $x \not< y$.

(ii) A family becomes literate if the woman in it is literate.

Solution:

Let p : The woman in the family is literate.

q : A family become literate.

Then the symbolic form of the given statement is $p \rightarrow q$

Converse : $q \rightarrow p$ is the converse of $p \rightarrow q$.

i.e. If a family become literate, then the woman in it is literate.

Inverse : $\sim p \rightarrow \sim q$ is the inverse of $p \rightarrow q$.

i.e. If the woman in the family is not literate, then the family does not become literate.

Contrapositive : $\sim q \rightarrow \sim p$ is the contrapositive of $p \rightarrow q$. i e. If a family does not become literate, then the woman in it is not literate.

(iii) If surface area decreases then pressure increases.

Solution:

Let p : The surface area decreases.

q : The pressure increases.

Then the symbolic form of the given statement is $p \rightarrow q$.

Converse : $q \rightarrow p$ is the converse of $p \rightarrow q$.

i.e. If the pressure increases, then the surface area decreases.

Inverse : $\sim p \rightarrow \sim q$ is the inverse of $p \rightarrow q$.

i.e. If the surface area does not decrease, then the pressure does not increase.

Contrapositive : ~q → ~p is the contrapositive of p → q.

i.e. If the pressure does not increase, then the surface area does not decrease.

(iv) If voltage increases then current decreases.

Solution:

Let p : Voltage increases.

q : Current decreases.

Then the symbolic form of the given statement is p → q.

Converse : q →p is the converse of p → q.

i.e. If current decreases, then voltage increases.

Inverse : ~p → ~q is the inverse of p → q.

i.e. If voltage does not increase, then current does not decrease.

Contrapositive : ~q → ~p, is the contrapositive of p → q.

i.e. If current does not decrease, then voltage doesnot increase.

Ex 1.4

Question 1.

Using rules of negation write the negations of the following with justification.

(i) ~q → p

Solution:

The negation of ~q → p is

~(~q → p) ≡ ~ q ∧ ~p…. (Negation of implication)

(ii) p ∧ ~q

Solution:

The negation of p ∧ ~q is

~(p ∧ ~q) ≡ ~p ∨ ~(~q) … (Negation of conjunction)

≡ ~ p ∨ q … (Negation of negation)

(iii) p ∨ ~q

Solution:

The negation of p ∨ ~ p is

~ (p ∨ ~(q) ≡ ~p ∧ ~(~(q) … (Negation of disjunction)

≡ ~ p ∧ q … (Negation of negation)

(iv) (p ∨ ~q) ∧ r

Solution:

The negation of (p ∨ ~ q) ∧ r is

~[(p ∨ ~q) ∧ r] ≡ ~(p ∨ ~q) ∨ ~r … (Negation of conjunction)

≡ [~p ∧ ~(~q)] ∨ ~ r… (Negation of disjunction)

≡ (~ p ∧ q) ∧ ~ r … (Negation of negation)

(v) p → (p ∨ ~q)

Solution:

The negation of p → (p ∨ ~q) is

~ [p → (p ∨ ~q)] ≡ p ∧ ~ (p ∧ ~p) … (Negation of implication)

≡ p ∧ [~ p ∧ ~ (~(q)] … (Negation of disjunction)

≡ p ∧ (~ p ∧ q) (Negation of negation)

(vi) ~(p ∧ q) ∨ (p ∨ ~q)

Solution:

The negation of ~(p ∧ q) ∨ (p ∨ ~q) is

~[~(p ∧ q) ∨ (p ∨ ~q)] ≡ ~[~(p ∧ q)] ∧ ~(p ∨ ~q) … (Negation of disjunction)

≡ ~[~(p ∧ q)] ∧ [p ∧ ~(~q)] … (Negation of disjunction)

≡ (p ∧ q) ∧ (~ p ∧ q) … (Negation of negation)

(vii) (p ∨ ~q) → (p ∧ ~q)

Solution:

The negation of (p ∨ ~q) → (p ∧ ~q) is

~[(p ∨ ~q) → (p ∧ ~q)]

≡ (p ∨ ~q) ∧ ~(p ∧ ~q) … (Negation of implication)

≡ (p ∨ ~q) ∧ [~p ∨ ~(~q)] … (Negation of conjunction)

≡ (p ∨ ~q) ∧ (~p ∨ q) … (Negation of negation)

(viii) (~ p ∨ ~q) ∨ (p ∧ ~q)

Solution:

The negation of (~ p ∨ ~q) ∨ (p ∧ ~ q) is

~ [(~p ∨ ~q) ∨ (p ∧ ~ q)]

≡ ~(~p ∨ ~q) ∧ ~(p ∧ ~q) … (Negation of disjunction)

≡ [~(~p) ∧ ~(~q)] ∧ [~p ∨ ~(~q)] … (Negation of disjunction and conjunction)

≡ (p ∧ q) ∧ (~p ∨ q) … (Negation of negation)

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Question 2.

Rewrite the following statements without using if .. then.

(i) If a man is a judge then he is honest.

Solution:

Since $p \rightarrow \equiv \sim p \vee q$, the given statements can be written as :

A man is not a judge or he is honest.

(ii) It 2 is a rational number then $2-\sqrt{}$ is irrational number.

Solution:

2 is not a rational number or $2-\sqrt{}$ is irrational number.

(iii) It f(2) = 0 then f(x) is divisible by (x – 2).

Solution:

$f(2) \neq 0$ or f(x) is divisible by (x – 2).

Question 3.

Without using truth table prove that :

(i) $p \leftrightarrow q \equiv (p \wedge q) \vee (\sim p \wedge \sim q)$

Solution:

LHS = $p \leftrightarrow q$

$\equiv (p \leftrightarrow q) \wedge (q \leftrightarrow p)$ … (Biconditional Law)

$\equiv (\sim p \vee q) \wedge (\sim q \vee p)$ … (Conditional Law)

$\equiv [\sim p \wedge (\sim q \vee p)] \vee [q \wedge (\sim q \vee p)]$ … (Distributive Law)

$\equiv [(\sim p \wedge \sim q) \vee (\sim p \wedge p)] \vee [(q \wedge \sim q) \vee (q \wedge p)]$ … (Distributive Law)

≡ [(~p ∧ ~q) ∨ F] ∨ [F ∨ (q ∧ p)] … (ComplementLaw)

≡ (~ p ∧ ~ q) ∨ (q ∧ p) … (Identity Law)

≡ (~ p ∧ ~ q) ∨ (p ∧ q) … (Commutative Law)

≡ (p ∧ q) ∨ (~p ∧ ~q) … (Commutative Law)

≡ RHS.

(ii) (p ∨ q) ∧ (p ∨ ~q) ≡ p

Solution:

LHS = (p ∨ q) ∧ (p ∨ ~q)

≡ p ∨ (q ∧ ~q) … (Distributive Law)

≡ p ∨ F … (Complement Law)

≡ p … (Identity Law)

≡ RHS.

(iii) (p ∧ q) ∨ (~ p ∧ q) ∨ (p ∧ ~q) ≡ p ∨ q

Solution:

LHS = (p ∧ q) v (~p ∧ q) ∨ (p ∧ ~q)

≡ [(p ∨ ~p) ∧ q] ∨ (p ∧ ~q) … (Distributive Law)

≡ (T ∧ q) ∨ (p ∧ ~q) … (Complement Law)

≡ q ∨ (p ∧ ~q) … (Identity Law)

≡ (q ∨ p) ∧ (q ∨ ~q) … (Distributive Law)

≡ (q ∨ p) ∧ T .. (Complement Law)

≡ q ∨ p … (Identity Law)

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≡ p ∨ q … (Commutative Law)

≡ RHS.

(iv) ~[(p ∨ ~q) → (p ∧ ~q)] ≡ (p ∨ ~q) ∧ (~p ∨ q)

Solution:

LHS = ~[(p ∨ ~q) → (p ∧ ~q)]

≡ (p ∨ ~q) ∧ ~(p ∧ ~q) … (Negation of implication)

≡ (p ∨ ~q) ∧ [~p ∨ ~(~q)] … (Negation of conjunction)

≡ (p ∨ ~ q) ∧ (~p ∨ q)… (Negation of negation)

≡ RHS.

Ex 1.5

Question 1.

Express the following circuits in the symbolic form of logic and writ the input-output table.

(i)

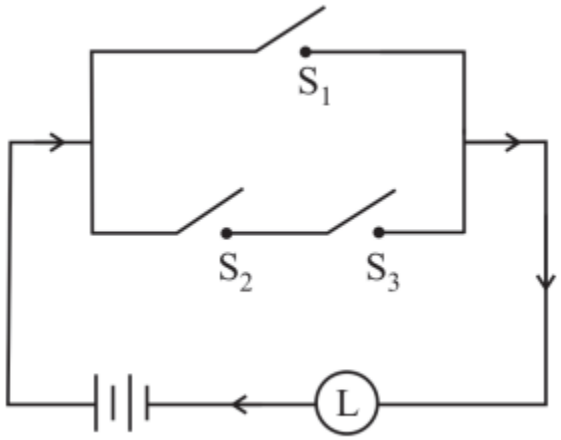


Fig. 1.17

Solution:

Let p : the switch S_1 is closed

q : the switch S_2 is closed

r : the switch S_3 is closed

~p : the switch S_1' is closed or the switch $S_1$is open

~q : the switch S_2' is closed or the switch S_2 is open

~r : the switch S_3' is closed or the switch S_3 is open

I : the lamp L is on

(i) The symbolic form of the given circuit is : $p \vee (q \wedge r) = I$

I is generally dropped and it can be expressed as : $p \vee (q \wedge r)$.

Input–Output Table

p	q	r	$q \wedge r$	$p \vee (q \wedge r)$
1	1	1	1	1
1	1	0	0	1
1	0	1	0	1
1	0	0	0	1
0	1	1	1	1
0	1	0	0	0
0	0	1	0	0
0	0	0	0	0

(ii)

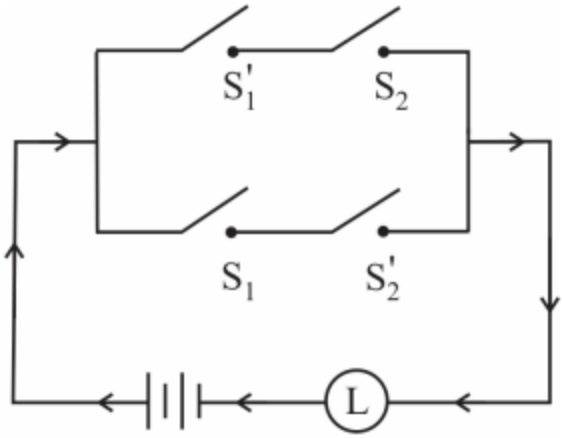


Fig. 1.18

Solution:

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

Input–Output Table

p	q	$\sim p$	$\sim q$	$\sim p \wedge q$	$p \wedge \sim q$	$(\sim p \wedge q) \vee (p \wedge \sim q)$
1	1	0	0	0	0	0
1	0	0	1	0	1	1
0	1	1	0	1	0	1
0	0	1	1	0	0	0

(iii)

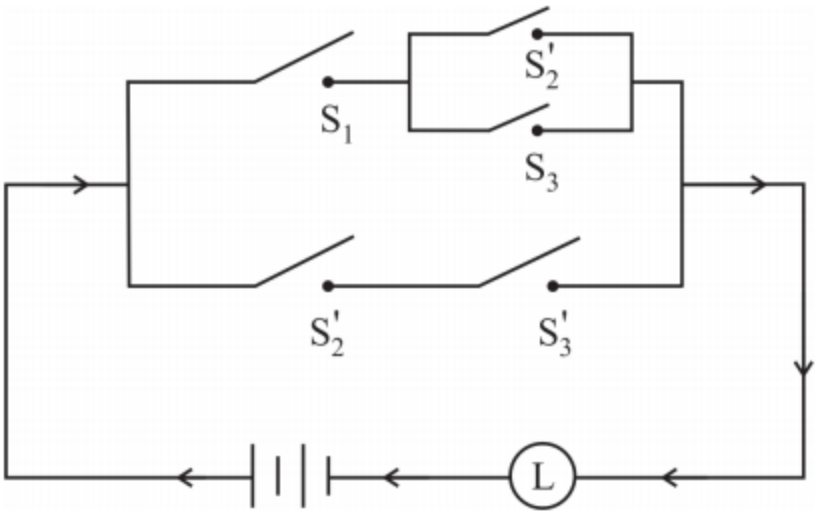


Fig. 1.19

Solution:

The symbolic form of the given circuit is : [p ∧ (~q ∨ r)] ∨ (~q ∧ ~ r).

Input–Output Table

p	q	r	$\sim q$	$\sim r$	$\sim q \vee r$	$p \wedge (\sim q \vee r)$	$\sim q \wedge \sim r$	$[p \wedge (\sim q \vee r)] \vee (\sim q \wedge \sim r)$
1	1	1	0	0	1	1	0	1
1	1	0	0	1	0	0	0	0
1	0	1	1	0	1	1	0	1
1	0	0	1	1	1	1	1	1
0	1	1	0	0	1	0	0	0
0	1	0	0	1	0	0	0	0
0	0	1	1	0	1	0	0	0
0	0	0	1	1	1	0	1	1

(iv)

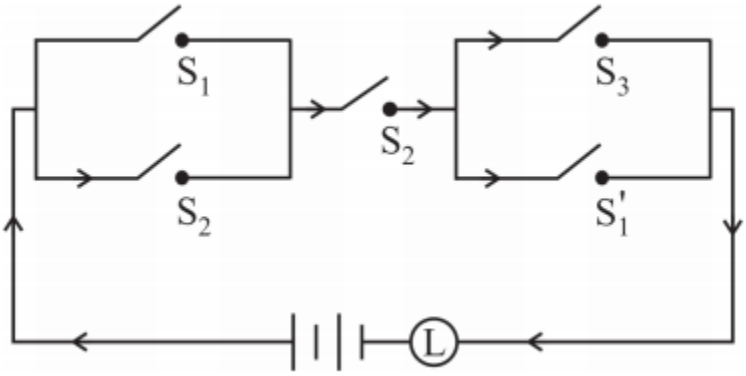


Fig. 1.20

Solution:

The symbolic form of the given circuit is : $(p \vee q) \wedge q \wedge (r \vee \sim p)$.

(v)

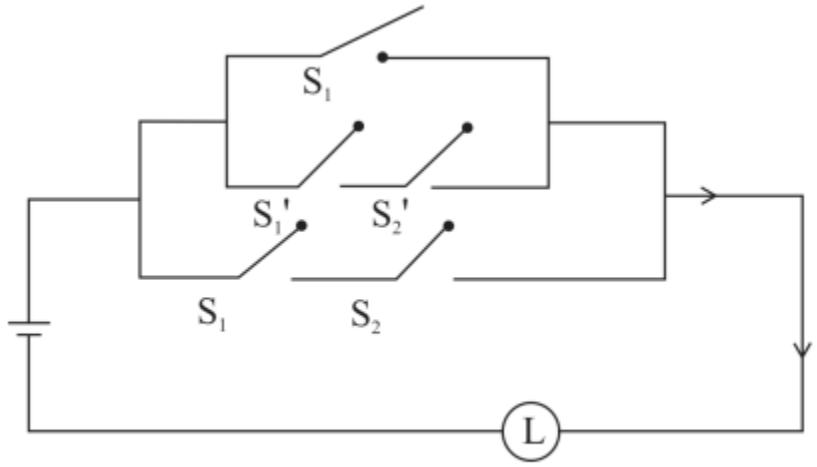


Fig. 1.21

Solution:

The symbolic form of the given circuit is : [p ∨ (~p ∧ ~q)] ∨ (p ∧ q).

Input–Output Table

p	q	$\sim p$	$\sim q$	$\sim p \wedge \sim q$	$p \vee (\sim p \wedge \sim q)$	$p \wedge q$	$[p \vee (\sim p \wedge \sim q)] \vee (p \wedge q)$
1	1	0	0	0	1	1	1
1	0	0	1	0	1	0	1
0	1	1	0	0	0	0	0
0	0	1	1	1	1	0	1

(vi)

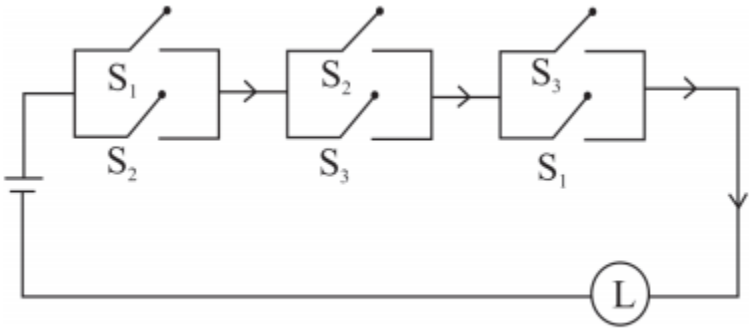


Fig. 1.22

Solution:

The symbolic form of the given circuit is : (p ∨ q) ∧ (q ∨ r) ∧ (r ∨ p)

Input–Output Table

p	q	r	$p \vee q$	$q \vee r$	$r \vee p$	$(p \vee q) \wedge (q \vee r) \wedge (r \vee p)$
1	1	1	1	1	1	1
1	1	0	1	1	1	1
1	0	1	1	1	1	1
1	0	0	1	0	1	0
0	1	1	1	1	1	1
0	1	0	1	1	0	0
0	0	1	0	1	1	0
0	0	0	0	0	0	0

Question 2.

Construct the switching circuit of the following :

(i) (~p ∧ q) ∨ (p ∧ ~r)

Solution:

Let p : the switch S_1 is closed

q : the switch S_2 is closed

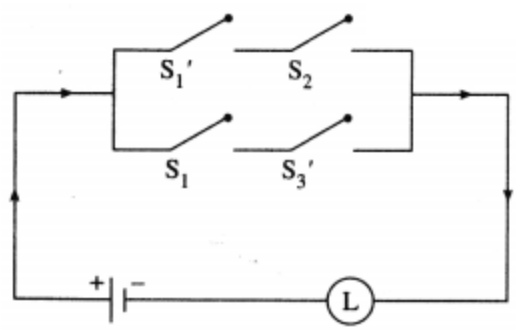
r : the switch S_3 is closed

~p : the switch S_1' is closed or the switch S_1 is open

~ q : the switch S_2' is closed or the switch S_2 is open

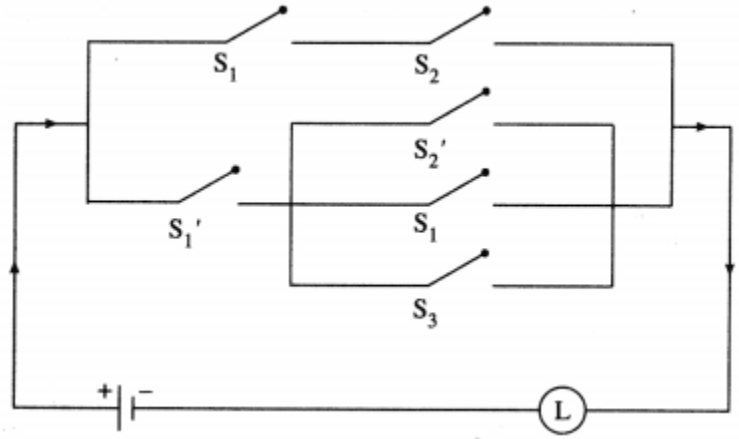
~ r : the switch S_3' is closed or the switch S_3 is open.

Then the switching circuits corresponding to the given statement patterns are :



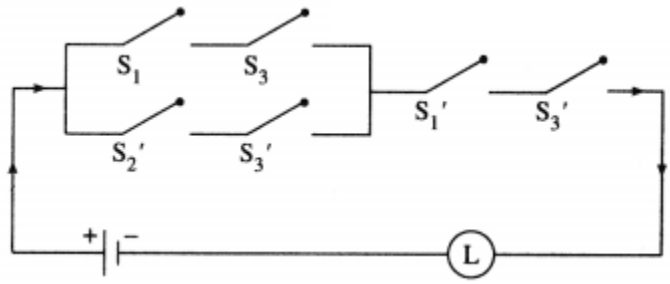
(ii) (p ∧ q) ∨ [~p ∧ (~q ∨ p ∨ r)]

Solution:



(iii) [(p ∧ r) ∨ (~q ∧ ~r)] ∧ (~p ∧ ~r)

Solution:



(iv) (p ∧ ~q ∧ r) ∨ [p ∧ (~q ∨ ~r)]

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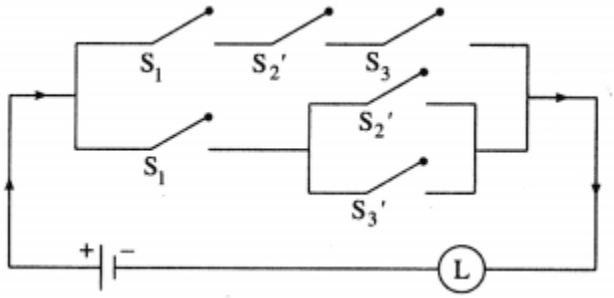
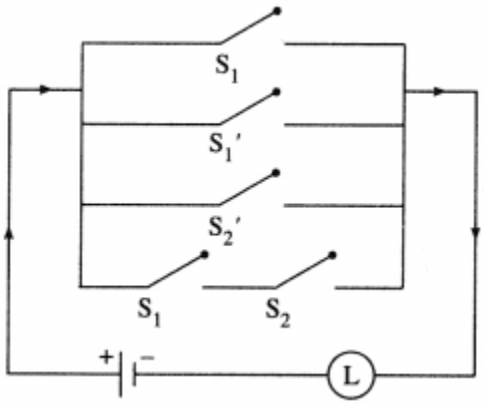
Solution:



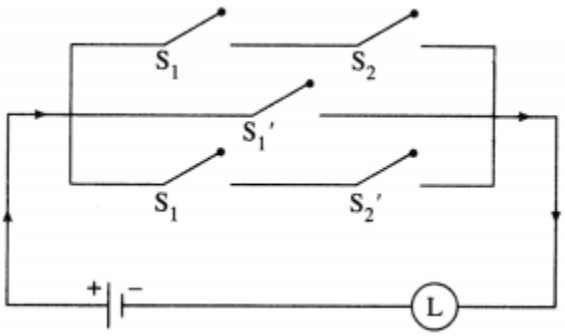
(v) p ∨ (~p) ∨ (~q) ∨ (p ∧ q)

Solution:



(vi) (p ∧ q) ∨ (~p) ∨ (p ∧ ~q)

Solution:



Question 3.

Give an alternative equivalent simple circuits for the following circuits :

(i)

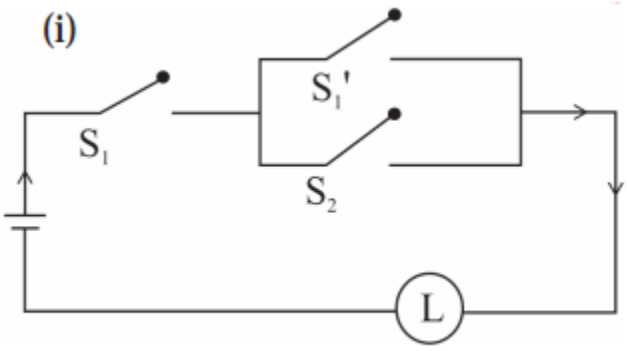


Fig. 1.23

Solution:

(i) Let p : the switch S_1 is closed

q : the switch S_2 is closed

~ p : the switch S_1' is closed or the switch Si is open Then the symbolic form of the given circuit is :

$p \wedge (\sim p \vee q)$.

Using the laws of logic, we have,

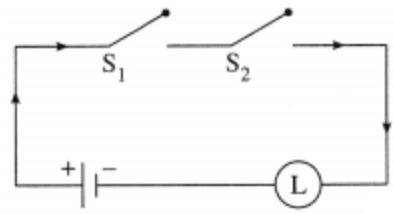
$p \wedge (\sim p \vee q)$

$= (p \wedge \sim p) \vee (p \wedge q)$ …(By Distributive Law)

$= F \vee (p \wedge q)$ … (By Complement Law)

$= p \wedge q$… (By Identity Law)

Hence, the alternative equivalent simple circuit is :



(ii)

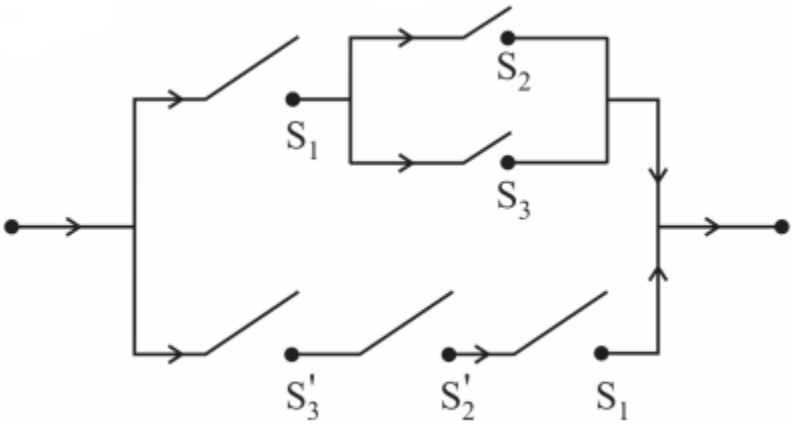


Fig. 1.24

Let p : the switch S_1 is closed

q : the switch S_2 is closed

r : the switch S_3 is closed

~q : the switch S_2‘ is closed or the switch S_2 is open

~r : the switch S_3‘ is closed or the switch S_3 is open.

Then the symbolic form of the given circuit is :

$[p \wedge (q \vee r)] \vee (\sim r \wedge \sim q \wedge p)$.

Using the laws of logic, we have

$[p \wedge (q \vee r)] \vee (\sim r \wedge \sim q \wedge p)$

≡ [p ∧ (q ∨ r)] ∨ [~(r ∨ q) ∧ p] …. (By De Morgan's Law)

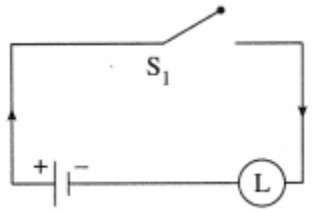
≡ [p ∧ (q ∨ r)] ∨ [p ∧ ~(q ∨ r)] … (By Commutative Law)

≡ p ∧ [(q ∨ r) ∨ ~(q ∨ r)) … (By Distributive Law)

≡ p ∧ T … (By Complement Law)

≡ p … (By Identity Law)

Hence, the alternative equivalent simple circuit is :



Question 4.

Write the symbolic form of the following switching circuits construct its switching table and interpret it.

i)

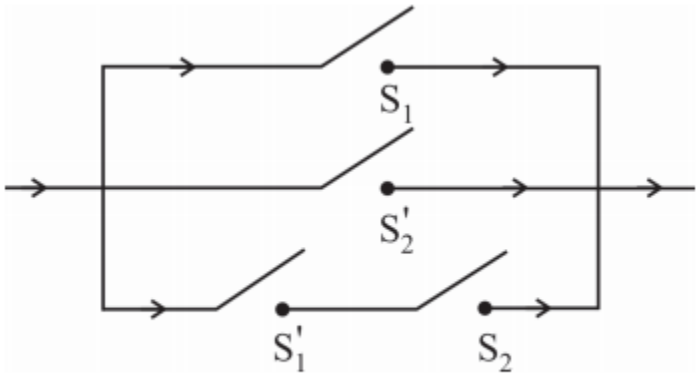


Fig. 1.25

Solution:

Let p : the switch S_1 is closed

q : the switch S_2 is closed

~p : the switch S_1' is closed or the switch S_1 is open

~ q : the switch S_2' is closed or the switch S_2 is open.

Then the symbolic form of the given circuit is :

(p ∨ ~q) ∨ (~p ∧ q)

Switching Table

p	q	$\sim p$	$\sim q$	$p \vee \sim q$	$\sim p \wedge q$	$(p \vee \sim q) \vee (\sim p \wedge q)$
1	1	0	0	1	0	1
1	0	0	1	1	0	1
0	1	1	0	0	1	1
0	0	1	1	1	0	1

Since the final column contains all' 1′, the lamp will always glow irrespective of the status of switches.

ii)

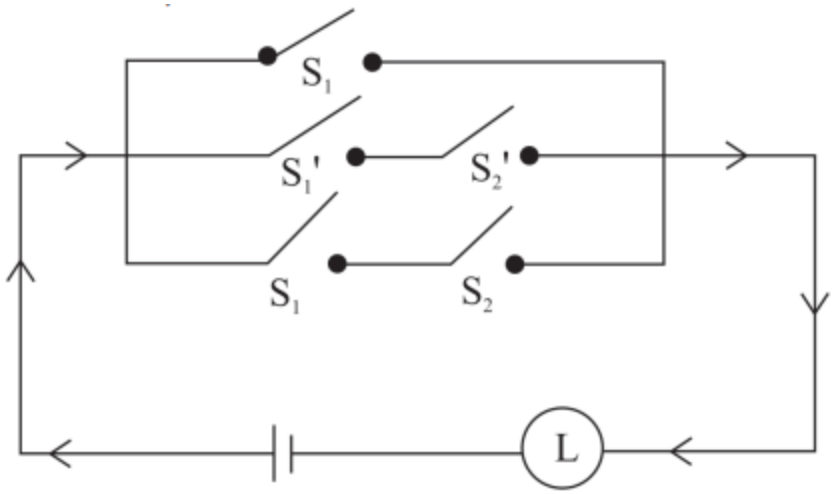


Fig. 1.26

Solution:

Let p : the switch S_1 is closed

q : the switch S_2 is closed

~p : the switch S_1 is closed or the switch S_1 is open.

~q : the switch S_2' is closed or the switch S_2 is open.

Then the symbolic form of the given circuit is : $p \vee (\sim p \wedge \sim q) \vee (p \wedge q)$

Switching Table

p	q	$\sim p$	$\sim q$	$\sim p \wedge \sim q$	$p \wedge q$	$p \vee (\sim p \wedge \sim q) \vee (p \wedge q)$
1	1	0	0	0	1	1
1	0	0	1	0	0	1
0	1	1	0	0	0	0
0	0	1	1	1	0	1

Since the final column contains '0' when p is 0 and q is '1', otherwise it contains '1'.

Hence, the lamp will not glow when S_1 is OFF and S_2 is ON, otherwise the lamp will glow.

iii)

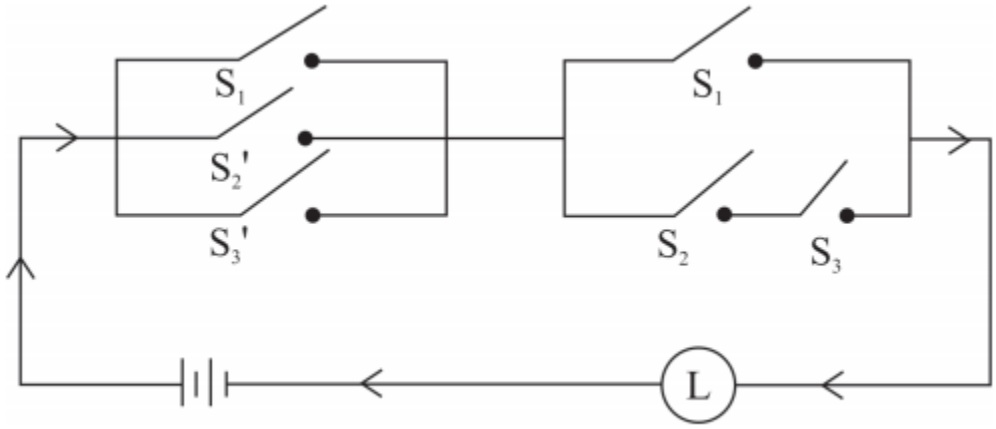


Fig. 1.27

Solution:

Let p : the switch S_1 is closed

q : the switch S_2 is closed

r : the switch S_3 is closed

~q : the switch S_2' is closed or the switch S_2 is open

~r: the switch S_3' is closed or the switch S_3 is open.

Then the symbolic form of the given circuit is : $[p \vee (\sim q) \vee r)] \wedge [p \vee (q \wedge r)]$

Switching Table

p	q	r	$\sim q$	$\sim r$	$p \vee (\sim q) \vee (\sim r)$ (I)	$q \wedge r$	$p \vee (q \wedge r)$ (II)	Final column (I) $\wedge$ (II)
1	1	1	0	0	1	1	1	1
1	1	0	0	1	1	0	1	1
1	0	1	1	0	1	0	1	1
1	0	0	1	1	1	0	1	1
0	1	1	0	0	0	1	1	0
0	1	0	0	1	1	0	0	0
0	0	1	1	0	1	0	0	0
0	0	0	1	1	1	0	0	0

From the switching table, the 'final column' and the column of p are identical. Hence, the lamp will glow which S_1 is 'ON'.

Question 5.

Obtain the simple logical expression of the following. Draw the corresponding switching circuit.

(i) p $\vee$ (q $\wedge$ ~ q)

Solution:

Using the laws of logic, we have, p $\vee$ (q $\wedge$ ~q)

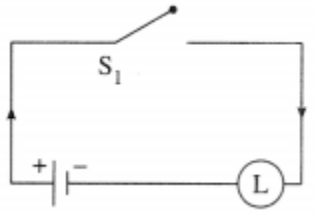
$\equiv$ p $\vee$ F … (By Complement Law)

$\equiv$ p … (By Identity Law)

Hence, the simple logical expression of the given expression is p.

Let p : the switch S_1 is closed

Then the corresponding switching circuit is :



(ii) (~p ∧ q) ∨ (~p ∧ ~q) ∨ (p ∧ ~q)]

Solution:

Using the laws of logic, we have,

(~p ∧ q) ∨ (~p ∨ ~q) ∨ (p ∧ ~q)

≡ [~p ∧ (q ∨ ~q)] ∨ (p ∧ ~ q)… (By Distributive Law)

≡ (~p ∧ T) ∨ (p ∧ ~q) … (By Complement Law)

≡ ~p ∨ (p ∧ ~q) … (By Identity Law)

≡ (~p ∨ p) ∧ (~p ∧~q) … (By Distributive Law)

≡ T ∧ (~p ∧ ~q) … (By Complement Law)

≡ ~p ∨ ~q … (By Identity Law)

Hence, the simple logical expression of the given expression is ~ p ∨ ~q.

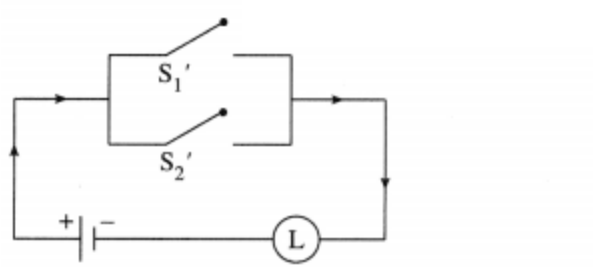
Let p : the switch S_1 is closed

q : the switch S_2 is closed

~ p : the switch S_1‘ is closed or the switch S_1 is open

~ q : the switch S_2‘ is closed or the switch S_2 is open,

Then the corresponding switching circuit is :



(iii) [p (∨ (~q) ∨ ~r)] ∧ (p ∨ (q ∧ r)

Solution:

Using the laws of logic, we have,

[p ∨ (~ (q) ∨ (~r)] ∧ [p ∨ (q ∧ r)]

= [p ∨ { ~(q ∧ r)}] ∧ [p ∨ (q ∧ r)] … (By De Morgan's Law)

= p ∨ [~(q ∧ r) ∧ (q ∧ r)] … (By Distributive Law)

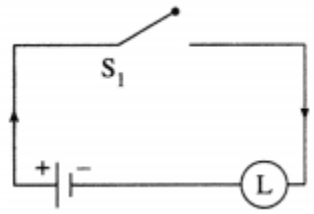
= p ∨ F … (By Complement Law)

= p … (By Identity Law)

Hence, the simple logical expression of the given expression is p.

Let p : the switch S_1 is closed

Then the corresponding switching circuit is :



(iv) (p ∧ q ∧ ~p) ∨ (~p ∧ q ∧ r) ∨ (p ∧ ~q ∧ r) ∨ (p ∧ q ∧ r)

Question is Modified

$(p \wedge q \wedge \sim p) \vee (\sim p \wedge q \wedge r) \vee (p \wedge q \wedge r)$

Solution:

Using the laws of logic, we have,

$(p \wedge q \wedge \sim p) \vee (\sim p \wedge q \wedge r) \vee (p \wedge q \wedge r)$

$= (p \wedge \sim p \wedge q) \vee (\sim p \wedge q \wedge r) \vee (p \wedge q \wedge r)$ … (By Commutative Law)

$= (F \wedge q) \vee (\sim p \wedge q \wedge r) \vee (p \wedge q \wedge r)$ … (By Complement Law)

$= F \vee (\sim p \wedge q \wedge r) \vee (p \wedge q \wedge r)$ … (By Identity Law)

$= (\sim p \wedge q \wedge r) \vee (p \wedge q \wedge r)$ … (By Identity Law)

$= (\sim p \vee p) \wedge (q \wedge r)$ … (By Distributive Law)

$= T \wedge (q \wedge r)$ … (By Complement Law)

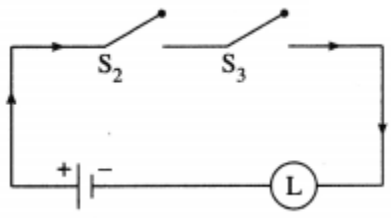
$= q \wedge r$ … (By Identity Law)

Hence, the simple logical expression of the given expression is $q \wedge r$.

Let q : the switch S_2 is closed

r : the switch S_3 is closed.

Then the corresponding switching circuit is :



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