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Unit – 2 ⇝ Recurrence Relation and Propositional Logic

Unit – 2.1 ⇝ Recurrence Relation

Method – 2 ⇝ Solution of Linear Recurrence Relation using Undetermined Coefficient Method

Examples of Method-2: Solution of Linear Recurrence Relation using Undetermined Coefficient Method

A	1	Solve the recurrence relations $a_n = 6a_{n-1}$ using the method of undetermined coefficients. **Answer:** $\mathbf{C_1(6)^n}$
A	2	Solve the recurrence relations $a_n = a_{n-1} + 2a_{n-2}$ using the method of undetermined coefficients. **Answer:** $\mathbf{C_1(2)^n + C_2(-1)^n}$
A	3	Solve the recurrence relations $a_n = 9a_{n-1} - 27a_{n-2} + 27a_{n-3}$ using the method of undetermined coefficients. **Answer:** $\mathbf{(C_1 + C_2 n + C_2 n^2)(3)^n}$
B	4	Solve the following recurrence relations using the method of undetermined coefficients: **(1)** $a_n - 7a_{n-1} + 10a_{n-2} = 0$; $a_0 = 0,\ a_1 = 3$ **(2)** $a_n + 2a_{n-1} - 15a_{n-2} = 0$; $a_0 = 0,\ a_1 = 1$ **(3)** $a_n = 2a_{n-1} - a_{n-2}$; $a_1 = 1.5,\ a_2 = 3$ **(4)** $a_n - 4a_{n-1} + 4a_{n-2} = 0$; $a_0 = 1,\ a_1 = 6$ **Answer :** (1) $\mathbf{a_n = (5)^n - (2)^n}$ (2) $\mathbf{a_n = \frac{1}{8}(3)^n - \frac{1}{8}(-5)^n}$ (3) $\mathbf{a_n = (1.5n)(1)^n}$ (4) $\mathbf{a_n = (1 + 2n)(2)^n}$

C	5	Find the unique solution to recurrence relation with the given initial conditions: $a_n = 10a_{n-1} - 32a_{n-2} + 32a_{n-3}$; $n \geq 3,\ a_0 = 5,\ \ a_1 = 18,\ \ a_2 = 76$ **Answer**: $\mathbf{a_n = (2+n)(4)^n + 3(2)^n}$
B	6	Find solution to recurrence relation with the given initial conditions: $a_n = 5a_{n-1} + 3$; $n \geq 1,\ a_1 = 2$ **Answer**: $\mathbf{a_n = \frac{11}{20}(5)^n - \frac{3}{4}}$
B	7	Solve the given recurrence relation using the method of undetermined coefficients $a_n - a_{n-1} - 2a_{n-2} = n^2$; $n \geq 2$. **Answer**: $\mathbf{a_n = C_1(-1)^n + C_2(2)^n - 4 - \frac{5}{2}n - \frac{1}{2}n^2}$
B	8	Solve the given recurrence relation using the method of undetermined coefficients $a_n = 2a_{n-1} + 3a_{n-2} + 5^n$; $n \geq 2,\ \ a_0 = -2,\ \ a_1 = 1$. **Answer**: $\mathbf{a_n = -\frac{17}{24}(-1)^n - \frac{27}{8}(3)^n + \frac{25}{12}(5)^n}$
C	9	Solve the given recurrence relation $a_n - 4a_{n-1} + 4a_{n-2} = n + 3^n$ using undetermined coefficients method. **Answer** : $\mathbf{a_n = (C_1 + C_2 n)(2)^n + 4 + n + (3)^{n+2}}$
C	10	Solve the given recurrence relation using the method of undetermined coefficients $a_n = 5a_{n-1} - 6a_{n-2} + 2^n + 3n$; $n \geq 2,\ \ a_0 = 2,\ \ a_1 = -2$. **Answer**: $\mathbf{a_n = -5(2)^n + \frac{7}{4}(3)^n - n2^{n+1} + \frac{21}{4} + \frac{3}{2}n}$

Unit – 2.2 ⇝ Propositional Logic

Method 1 ⇝ Statements

Examples of Method-1: Statements

A	1	Which of the following are proposition? p : Do not go. q : 4 > 3 r : 4 is an integer. **Answer: q and r are proposition**
A	2	Which of the following are not proposition? p : $x \in \{8, 9, 10, 11\}$ q : $2 > 3$ r : x is perfect square. **Answer: p and r are not proposition**
A	3	Which of the following are proposition? p : grass is green. q : $2 + 5 = 5$ s : Javaharlal Nehru is the first prime minister of india. **Answer: p, q and s are proposition**
A	4	Which of the following are proposition? p : Look Out! q : How far is it to the next town? r : $x + 2 = 2x$ s : $x + 2 = 2x$ when $x = -2$ **Answer: s is a proposition**

A	5	Which of the following are proposition? p : 5 is a Prime Number. q : 8 is an odd number. r : Did you lock the door? s : Happy Birthday! **Answer: p and q are proposition**
A	6	Assign the truth value to the following sentences if it is proposition. p : 4 is an integer. q : 4 > 7 r : India Won cricket world cup of 1983. s : You are innocent. **Answer: p : T, q : F, r : T,** **s : No truth value as it is not a proposition**
A	7	Assign the truth value to the following sentences if it is proposition. p : Water boils at 100 degrees celsius at sea level. q : All birds can fly. r : Sum of angles of triangle is 360°. s : The sky is blue. **Answer: p : T, q : F, r : F,** **s : No truth value as it is not a proposition**
A	8	Assign the truth value to the following sentences if it is proposition. p : Dublin is a capital of Ireland. q : $5 - 11 = 7$ r : 2 is an even number. s : Kuala Lumpur is the capital of Malasia. t : You and me. **Answer: p : T, q : F, r : T, s : T,** **t : No truth value as it is not a proposition**

A	9	Assign the truth value to the following sentences if it is proposition. p : How are you? q : Bangkok is the capital of Thailand. r : September has 30 days. s : A square has five sides. t : A cow has 12 legs. **Answer**: **p : No truth value as it is not a proposition, q : T,** **r : F, s : F,** **t : F**
A	10	Assign the truth value to the following sentences if it is proposition. p : A triangle has 3 sides. q : 57 is a prime number. r : $12 + (-4) = 8$ s : London is the capital of England. **Answer**: **p : T, q : F, r : T, s : T**

Method 2 ⇝ Logical Connectives

Examples of Method-2.1: Conjunction

A	1	Find the conjunction of propositions p and q. Where, p : Shyam is happy. q : Shyam is rich. **Answer: Shyam is happy and he is rich.**
A	2	Find the conjunction of propositions p and q. Where, p : Today is Monday. q : It is raining today. **Answer: Today is Monday and it is rainning.**
A	3	Define truth value for the following conjunction: **(1)** $4 + 2 = 6$ and Virat Kohli won the gold medal in Olympic. **(2)** Sardar Patel was born in Guajrat and he was a lawyer. **Answer: (1) F, (2) T**
A	4	Define truth value for following conjunction: **(1)** All rational numbers are complex numbers and $2 + 8 = 10$. **(2)** $x + 2 = 6$ if $x = 4$ and $x + 2 = 6$ if $x = 6$. **Answer: (1) F, (2) F**
A	5	Determine truth value for following conjunction: **(1)** Paris is in France and London is in England. **(2)** $x + 3 = 6$ if $x = 8$ and $x + 5 = 6$ if $x = 10$ **Answer: (1) T, (2) F**

B	6	Construct the truth table for $(q \wedge r)$. **Answer**: See table below

q	r	$(q \wedge r)$
T	T	T
T	F	F
F	T	F
F	F	F

Examples of Method-2.2: Disjunction

A	1	Find the disjunction of propositions p and q. Where, p : Mohan is scientist. q : Shyam is scientist. **Answer: Mohan is scientist or Shyam is scientist.**
A	2	Find the disjunction of propositions p and q. Where, p : Today is Monday. q : It is raining today. **Answer: Today is Monday or it is rainning .**
A	3	Define truth value for following disjunction: **(1)** Tata group was title sponsor of IPL 2023 or Amazon was title sponsor of IPL 2023. **(2)** Penguin can fly or Ostrich can fly. **Answer: (1) T, (2) F**
A	4	Define truth value for following disjunction: **(1)** Square root of negative number is natural number or square root of negative number is real number. **(2)** An acute angle measures less than 90° or right-angle measures less than 90°. **Answer: (1) F, (2) T**

Examples of Method-2.3: Negation

A	1	Write negation for each of the following propositions: p : Robin is present. q : He has money to purchase food. r : She will accept my proposal. s : Everybody will talk during the program. **Answer**: **¬p : Robin is not present.** **¬q : He has no money to purchase food.** **¬r : She will never accept my proposal.** **¬s : Nobody will talk during the program.**
A	2	Write negation for each of the following propositions: p : James and Jack mentioned this place in their tutoring place. q : She can make coockies and pasta for all of us. r : I am going to school. **Answer**: **¬p : Neither James nor Jack mentioned this place in their tutoring place.** **¬q : She can neither make coockies nor pasta for all of us.** **¬r : I am not going to school.**

B	3	Translate the following symbolic form into sentences: **(1)** $\neg r \wedge q$ **(2)** $\neg q \vee p$ **(3)** $\neg p \wedge \neg q$ **(4)** $p \vee \neg r$ Where, p : Today I am not happy. q : The river is clean. r : $3 > 2$ **Answer**: (1) **$3 \ngtr 2$ and the river is clean.** (2) **The river is not clean or today i am not happy.** (3) **Today i am happy and the river is not clean.** (4) **Today I am not happy or $3 \ngtr 2$.**
B	4	Construct the truth table for compound propositions $p \vee \neg q$. **Answer**: (table below)
B	5	Construct the truth table for compound propositions $\neg(\neg p \vee \neg q)$. **Answer**: (table below)

B 4 Answer:

p	q	$p \vee \neg q$
T	T	T
T	F	T
F	T	F
F	F	T

B 5 Answer:

p	q	$\neg(\neg p \vee \neg q)$
T	T	T
T	F	F
F	T	F
F	F	F

Examples of Method-2.4: Conditional

B	1	Express the following statements in symbolic form: For, p : It is cold. q : It is raining. **(1)** If it is cold, then it is raining. **(2)** If it is raining, then it is cold. **(3)** If it is not raining, then it is not cold. **(4)** If it is not cold, then it is raining. **Answer: (1) $p \to q$, (2) $q \to p$, (3) $\neg q \to \neg p$, (4) $\neg p \to q$**
B	2	Express the following statements in symbolic form: For, p : The material is interesting. q : The exercise are challenging. r : The course is enjoyable. **(1)** If the material is interesting, then the exercise are challenging and conversely. **(2)** If material is not interesting and exercise are not challenging, then the course is not enjoyable. **Answer: (1) $(p \to q) \wedge (q \to p)$, (2) $(\neg p \wedge \neg q) \to \neg r$**
B	3	Express the following compound propositions as an English sentence by using p, q : Where, p : It is below freezing. q : It is snowing. **(1)** $q \to p$ **(2)** $\neg q \to \neg p$ **(3)** $\neg p \to \neg q$ **Answer: (1) If It is snowing, then it is below freezing.** **(2) If It is not snowing, then it is not below freezing.** **(3) If It is not below freezing, then it is not snowing.**

B	4	Determine whether the following conditional statements are true or false: **(1)** If $1+1=3$, then $2+3=5$. **(2)** If $1+1=3$, then dogs can fly. **(3)** If $1+1=2$, then cats can fly. **(4)** If $2+2=4$, then $1+2=3$. **Answer**: **(1) T, (2) T, (3) F, (4) T**
B	5	Construct the truth table for $(p \vee \neg q) \rightarrow q$. **Answer**: **p | q | $(p \vee \neg q) \rightarrow q$** **T | T | T** **T | F | F** **F | T | T** **F | F | F**
B	6	Construct the truth table for $(p \rightarrow q) \vee (\neg p \rightarrow q)$. **Answer**: **p | q | $(p \rightarrow q) \vee (\neg p \rightarrow q)$** **T | T | T** **T | F | T** **F | T | T** **F | F | T**
B	7	Express the inverse, converse and contrapositive statements of conditional statement given below: “If a man is a gentleman, then he is considerate of others”. **Answer**: **(1) Converse: "If man is considerate of others, then he is a gentleman".** **(2) Inverse: "If man is not a gentleman, then he is not considerate of others".** **(3) Contrapositive: "If man is not considerate of others, then he is not a gentleman".**

B	8	Express the inverse and contrapositive statements of converse statement given below: "If a steel rod stretches, then it has been heated". **Answer: (1) Inverse: "If a steel rod does not stretch, then it has not been heated".** **(2) Contrapositive: "If it has not been heated, then steel rod does not stretch".**
B	9	Express the inverse and contrapositive statements of conditional statement given below: "If x is rational, then x is real". **Answer: (1) Inverse: "If x is not rational, then x is not real"** **(2) Contrapositive: "If x is not real, then x is not rational"**

Examples of Method-2.5: Biconditional

<table>
<tr><td>A</td><td>1</td><td>Determine whether each of the following biconditional statements is true or false:
(1) $1 + 1 = 3$ if and only if $2 + 3 = 5$.
(2) $1 + 1 = 3$ if and only if dogs can fly.
(3) $1 + 1 = 2$ if and only if cats can fly.
(4) $2 + 2 = 4$ if and only if $1 + 2 = 3$.

Answer: (1)F , (2) T, (3) F, (4) T</td></tr>
<tr><td>B</td><td>2</td><td>Construct the truth table for $(p \rightarrow q) \rightleftarrows (\neg p \vee q)$.

Answer:
<table>
<tr><th>p</th><th>q</th><th>$(p \rightarrow q) \rightleftarrows (\neg p \vee q)$</th></tr>
<tr><td>T</td><td>T</td><td>T</td></tr>
<tr><td>T</td><td>F</td><td>T</td></tr>
<tr><td>F</td><td>T</td><td>T</td></tr>
<tr><td>F</td><td>F</td><td>T</td></tr>
</table></td></tr>
<tr><td>C</td><td>3</td><td>Construct the truth table for $(\neg p \rightleftarrows \neg q) \rightleftarrows (p \rightleftarrows q)$.

Answer:
<table>
<tr><th>p</th><th>q</th><th>$(\neg p \rightleftarrows \neg q) \rightleftarrows (p \rightleftarrows q)$</th></tr>
<tr><td>T</td><td>T</td><td>T</td></tr>
<tr><td>T</td><td>F</td><td>T</td></tr>
<tr><td>F</td><td>T</td><td>T</td></tr>
<tr><td>F</td><td>F</td><td>T</td></tr>
</table></td></tr>
<tr><td>C</td><td>4</td><td>Construct the truth table for $(p \rightleftarrows q) \rightleftarrows \big((p \wedge q) \vee (\neg p \wedge q)\big)$.

Answer:
<table>
<tr><th>p</th><th>q</th><th>$(p \rightleftarrows q) \rightleftarrows \big((p \wedge q) \vee (\neg p \wedge q)\big)$</th></tr>
<tr><td>T</td><td>T</td><td>T</td></tr>
<tr><td>T</td><td>F</td><td>T</td></tr>
<tr><td>F</td><td>T</td><td>F</td></tr>
<tr><td>F</td><td>F</td><td>F</td></tr>
</table></td></tr>
</table>

C	5	Construct the truth table for $\neg(p \vee (q \wedge r)) \rightleftarrows ((p \vee q) \wedge (p \vee r))$.

Answer:

p	q	r	$\neg(p \vee (q \wedge r)) \rightleftarrows ((p \vee q) \wedge (p \vee r))$
T	T	T	F
T	T	F	F
T	F	T	F
T	F	F	F
F	T	T	F
F	T	F	F
F	F	T	F
F	F	F	F

Method 3 ⇝ Precedence Rule

Examples of Method-3: Precedence Rule

A	1	By using preference rule put parentheses at appropriate place for following compound propositions: **(1)** $p \to q \rightleftarrows p \wedge \neg p \vee \neg q$ **(2)** $\neg p \wedge q \to \neg p \vee \neg q$ **(3)** $(p \to q) \wedge q \to r) \to (p \to r)$ **Answer**: (1) $(\mathbf{p} \to \mathbf{q}) \rightleftarrows \big(\mathbf{p} \wedge ((\neg \mathbf{p}) \vee (\neg \mathbf{q}))\big)$ (2) $((\neg \mathbf{p}) \wedge \mathbf{q}) \to ((\neg \mathbf{p}) \vee (\neg \mathbf{q}))$ (3) $\big(((\mathbf{p} \to \mathbf{q}) \wedge \mathbf{q}) \to \mathbf{r}\big) \to (\mathbf{p} \to \mathbf{r})$
A	2	By using preference rule put parentheses at appropriate place for following compound propositions: **(1)** $p \vee q \to \neg p \wedge \neg q$ **(2)** $p \vee q \vee r \to \neg p \vee r$ **(3)** $p \wedge \neg p \vee \neg q \to q$ **Answer**: (1) $(\mathbf{p} \vee \mathbf{q}) \to ((\neg \mathbf{p}) \wedge (\neg \mathbf{q}))$ (2) $((\mathbf{p} \vee \mathbf{q}) \vee \mathbf{r}) \to ((\neg \mathbf{p}) \vee \mathbf{r})$ (3) $\big((\mathbf{p} \wedge (\neg \mathbf{p})) \vee (\neg \mathbf{q})\big) \to \mathbf{q}$

Method 4 ⇝ Well Formed Formula

Examples of Method-4: Well Formed Formula

A	1	Which of the following are not well-formed formula? **(1)** $(p \rightarrow (p \wedge q))$ **(2)** $\neg p \wedge \neg q$ **(3)** $(p \wedge q) \rightarrow q)$ **(4)** $p \wedge q \rightarrow \neg(p)$ **(5)** $(\neg p \vee (q \wedge r))$ **Answer**: (**2**), (**3**), (**4**)
A	2	Which of the following are well-formed formula? **(1)** $((p \rightarrow q) \wedge (q \rightarrow r)) \rightarrow (p \rightarrow r)$ **(2)** $(p \rightarrow q) \rightarrow (\neg p \rightarrow \neg q)$ **(3)** $(p \wedge (\neg p \vee \neg q)) \rightarrow q$ **(4)** $((p \rightarrow r) \vee (q \rightarrow r)) \rightarrow ((p \vee q)) \rightarrow r)$ **Answer**: **None of them are well formed formula**
A	3	Which of the following are well-formed formula? **(1)** $((p \rightarrow r) \vee q)$ **(2)** $(((p \rightarrow r) \vee r) \vee p)$ **(3)** $(p \rightarrow (r \wedge (\neg p))) \rightarrow q$ **Answer**: (**1**), (**2**)

Method 5 ⇝ Tautologies

Examples of method-5: Tautologies

B	1	Show that the following propositions are tautology: **(1)** $p \vee \neg(p \wedge q)$ **(2)** $\neg(p \wedge q) \rightleftarrows \big((\neg p) \vee (\neg q)\big)$
B	2	Show that the following propositions are tautology: **(1)** $\big((p \to q) \wedge (q \to r)\big) \to (p \to r)$ **(2)** $\big((p \vee q) \wedge (\neg p \vee r)\big) \to (q \vee r)$
B	3	Show that the following propositions are contradictions: **(1)** $(\neg q \wedge p) \wedge q$ **(2)** $(p \wedge q) \wedge (\neg p \vee \neg q)$
B	4	Show that the following propositions are contradictions: **(1)** $p \wedge (\neg p \wedge q)$ **(2)** $(p \wedge q) \wedge \neg(p \vee q)$
B	5	Show that the following propositions are contingency: **(1)** $(p \wedge q) \rightleftarrows p$ **(2)** $\big(p \wedge (p \to \neg q)\big) \to q$
B	6	Show that the following propositions are contingency: **(1)** $(p \wedge q) \to \big(r \wedge (\neg p \wedge \neg q)\big)$ **(2)** $(p \to \neg q) \rightleftarrows (p \vee q)$

B	7	Check whether the given formulas are tautologies, contradiction or contingency. **(1)** $(p \rightarrow (p \vee q))$ **(2)** $(\neg p \rightarrow (p \rightarrow q))$ **(3)** $\neg(p \rightarrow q) \rightarrow p$ **(4)** $(p \wedge (p \rightarrow q)) \rightarrow q$ **(5)** $(\neg q \wedge (p \rightarrow q)) \rightarrow \neg p$ **(6)** $((p \wedge q) \rightleftarrows p)$ **Answer:** (1) **Tautology**, (2) **Tautology**, (3) **Tautology** (4) **Tautology**, (5) **Tautology**, (6) **contingency**

Method 6 ⇝ Equivalence of Formulas

Examples of Method-6: Logical Equivalence

B 1 Show that, $\neg(p \rightleftarrows q) \equiv (p \rightleftarrows \neg q)$.

Hint:

p	q	$p \rightleftarrows \neg q$
T	T	F
T	F	T
F	T	T
F	F	F

B 2 Show that $(p \rightarrow q) \equiv (\neg q \rightarrow \neg p)$.

Hint:

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

B 3 Show that, $\neg(p \vee q) \equiv (\neg p \wedge \neg q)$.

Hint:

p	q	$\neg(p \vee q)$
T	T	F
T	F	F
F	T	F
F	F	T

B 4 Show that, $\neg(p \wedge q) \equiv (\neg p \vee \neg q)$.

Hint:

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

B	5	Show that, $(p \rightleftarrows q) \equiv (p \rightarrow q) \wedge (q \rightarrow p)$.

Hint:

p	q	$(p \rightleftarrows q)$
T	T	T
T	F	F
F	T	F
F	F	T

B	6	Show that, $(p \rightarrow q) \wedge (p \rightarrow r) \equiv p \rightarrow (q \wedge r)$.

Hint:

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

B	7	Show that, $p \wedge (q \vee r) \equiv (p \wedge q) \vee (p \wedge r)$.

Hint:

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

B	8	Show that, $p \vee (q \wedge r) \equiv (p \vee q) \wedge (p \vee r)$.
B	9	Show that, $(p \to r) \wedge (q \to r) \equiv (p \vee q) \to r$.
B	10	Show that, $\neg p \to (q \to r) \equiv q \to (p \vee r)$.

Question 8

Hint:

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

Question 9

Hint:

p	q	r	$(p \vee q) \to r$
T	T	T	T
T	T	F	F
T	F	T	T
T	F	F	F
F	T	T	T
F	T	F	F
F	F	T	T
F	F	F	T

Question 10

Hint:

p	q	r	$\neg p \to (q \to r)$
T	T	T	T
T	T	F	T
T	F	T	T
T	F	F	T
F	T	T	T
F	T	F	F
F	F	T	T
F	F	F	T

Method 7 ⇝ Normal Forms

Examples of Method-7.1: Disjunctive Normal Form (DNF)

A	1	Find disjunctive normal form of $\neg(p \to (q \wedge r))$. **Answer**: $(\mathbf{p} \wedge \neg \mathbf{q}) \vee (\mathbf{p} \wedge \neg \mathbf{r})$
B	2	Find disjunctive normal form of $(p \to q) \wedge (q \to r)$. **Answer**: $(\neg \mathbf{p} \wedge \neg \mathbf{q}) \vee (\mathbf{q} \wedge \neg \mathbf{q}) \vee (\neg \mathbf{p} \wedge \mathbf{r}) \vee (\mathbf{q} \wedge \mathbf{r})$
C	3	Find disjunctive normal form of $(p \to q) \wedge (\neg p \wedge q)$. **Answer**: $(\neg \mathbf{p} \wedge \mathbf{q}) \vee (\mathbf{q} \wedge \neg \mathbf{p})$
B	4	Find disjunctive normal form of $(p \wedge (p \to q)) \to q$. **Answer**: $\neg \mathbf{p} \vee (\mathbf{p} \wedge \neg \mathbf{q}) \vee \mathbf{q}$

Examples of Method-7.2: Conjunctive Normal Form

C	1	Find conjunctive normal form of $\neg(p \wedge q) \rightleftarrows (p \wedge q)$. **Answer**: $(\mathbf{p} \vee \mathbf{q}) \wedge (\neg\mathbf{p} \vee \neg\mathbf{q})$
B	2	Find conjunctive normal form of $p \wedge (p \rightarrow q)$. **Answer**: $\mathbf{p} \wedge (\neg \mathbf{p} \vee \mathbf{q})$
C	3	Find conjunctive normal form of $(p \wedge q) \vee (\neg p \wedge q \wedge r)$. **Answer**: $(\mathbf{p} \vee \mathbf{q}) \wedge (\mathbf{p} \vee \mathbf{r}) \wedge (\mathbf{q} \vee \neg \mathbf{p}) \wedge (\mathbf{q}) \wedge (\mathbf{q} \vee \mathbf{r})$
B	4	Find conjunctive normal form of $(\neg p \rightarrow r) \wedge (p \rightarrow q)$ **Answer**: $(\mathbf{p} \vee \mathbf{q}) \wedge (\mathbf{q} \vee \neg \mathbf{p})$
B	5	Find conjunctive normal form of $\neg\big((p \vee \neg q) \wedge \neg r\big)$. **Answer**: $(\neg \mathbf{p} \vee \mathbf{r}) \wedge (\mathbf{q} \vee \mathbf{r})$

Examples of Method-7.3: Principal Disjunctive Normal Form

A	1	Find principal disjunctive normal form of $\neg(p \to (q \wedge r))$. **Answer**: $(\mathbf{p} \wedge \mathbf{q} \wedge \neg\mathbf{r}) \vee (\mathbf{p} \wedge \neg\mathbf{q} \wedge \mathbf{r}) \vee (\mathbf{p} \wedge \neg\mathbf{q} \wedge \neg\mathbf{r})$
C	2	Find principal disjunctive normal form of $\neg(p \vee q) \rightleftarrows (p \wedge q)$. **Answer**: $(\mathbf{p} \wedge \neg\mathbf{q}) \vee (\neg\mathbf{p} \wedge \mathbf{q})$
A	3	Find principal disjunctive normal form of $\neg((p \vee \neg q) \wedge \neg r)$. **Answer**: $(\mathbf{p} \wedge \mathbf{q} \wedge \mathbf{r}) \vee (\mathbf{p} \wedge \neg\mathbf{q} \wedge \mathbf{r}) \vee (\neg\mathbf{p} \wedge \mathbf{q} \wedge \mathbf{r}) \vee (\neg\mathbf{p} \wedge \neg\mathbf{q} \wedge \mathbf{r})$
C	4	Find principal disjunctive normal form of $(p \to (q \wedge r)) \wedge (\neg p \to (\neg q \wedge \neg r))$. **Answer**: $(\mathbf{p} \wedge \mathbf{q} \wedge \mathbf{r}) \vee (\neg\mathbf{p} \wedge \neg\mathbf{q} \wedge \mathbf{r}) \vee (\neg\mathbf{p} \wedge \neg\mathbf{q} \wedge \neg\mathbf{r})$

Examples of Method-7.4: Principal Conjunctive Normal Form

A	1	Find principal conjunctive normal form of $\neg(p \rightarrow (q \wedge r))$. **Answer:** $(\mathbf{p} \vee \mathbf{q} \vee \mathbf{r}) \wedge (\neg \mathbf{p} \vee \mathbf{q} \vee \neg \mathbf{r}) \wedge (\neg \mathbf{p} \vee \neg \mathbf{q} \vee \mathbf{r}) \wedge (\neg \mathbf{p} \vee \neg \mathbf{q} \vee \neg \mathbf{r})$
B	2	Find principal conjunctive normal form of $\neg(p \rightleftarrows q)$. **Answer:** $(\mathbf{p} \vee \mathbf{q}) \wedge (\neg \mathbf{q} \vee \neg \mathbf{p})$
B	3	Find principal conjunctive normal form of $\neg((p \vee \neg q) \wedge \neg r)$. **Answer:** $(\neg \mathbf{p} \vee \neg \mathbf{q} \vee \mathbf{r}) \wedge (\mathbf{p} \vee \neg \mathbf{q} \vee \neg \mathbf{r}) \wedge (\neg \mathbf{p} \vee \neg \mathbf{q} \vee \neg \mathbf{r})$

***** End of the Unit *****