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PAIR OF LINEAR EQUATIONS IN TWO VARIABLES

Complete Study Material for CBSE Class 10

☀️ INTERESTING MATHEMATICAL FACTS

Did You Know?

- 🎯 **Ancient Origins:** Linear equations were used by ancient Babylonians around 1800 BC to solve problems about land measurement and taxation!
- 📱 **GPS Technology:** Your phone's GPS uses systems of linear equations to triangulate your exact position from satellite signals!
- 🚀 **Space Missions:** NASA uses pairs of linear equations to calculate rocket trajectories and plan interplanetary missions!

-  **Economics & Business:** Companies use linear equations to find break-even points, optimize profits, and make investment decisions!
-  **Computer Graphics:** Every line you see in video games and 3D animations is drawn using linear equations!

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CHAPTER OVERVIEW

Chapter	Pair of Linear Equations in Two Variables		
Weightage	6 Marks (as per CBSE marking scheme)		
Question Types	1 Mark: 1	3 Mark: 0	5 Mark: 1

Topics Covered:

1. Introduction to Pair of Linear Equations
2. Graphical Method of Solution
3. Algebraic Methods:
 - Substitution Method
 - Elimination Method
 - Cross Multiplication Method
4. Consistency and Inconsistency of Equations
5. Word Problems and Applications

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SECTION 1: BASIC CONCEPTS

Key Definitions

Linear Equation in Two Variables:

An equation of the form $ax + by + c = 0$, where a, b, c are real numbers and $a \neq 0$ or $b \neq 0$.

Examples: $2x + 3y = 6$, $x - 4y + 7 = 0$, $5x = 2y + 3$

Pair of Linear Equations:

Two linear equations in the same two variables considered together.

$$a_1x + b_1y + c_1 = 0$$

$$a_2x + b_2y + c_2 = 0$$

Types of Solutions:

Type	Condition	Graph Behavior	Number of Solutions
Consistent (Independent)	$a_1/a_2 \neq b_1/b_2$	Lines intersect at one point	Unique (One) Solution
Consistent (Dependent)	$a_1/a_2 = b_1/b_2 = c_1/c_2$	Lines coincide	Infinitely many solutions
Inconsistent	$a_1/a_2 = b_1/b_2 \neq c_1/c_2$	Lines are parallel	No solution

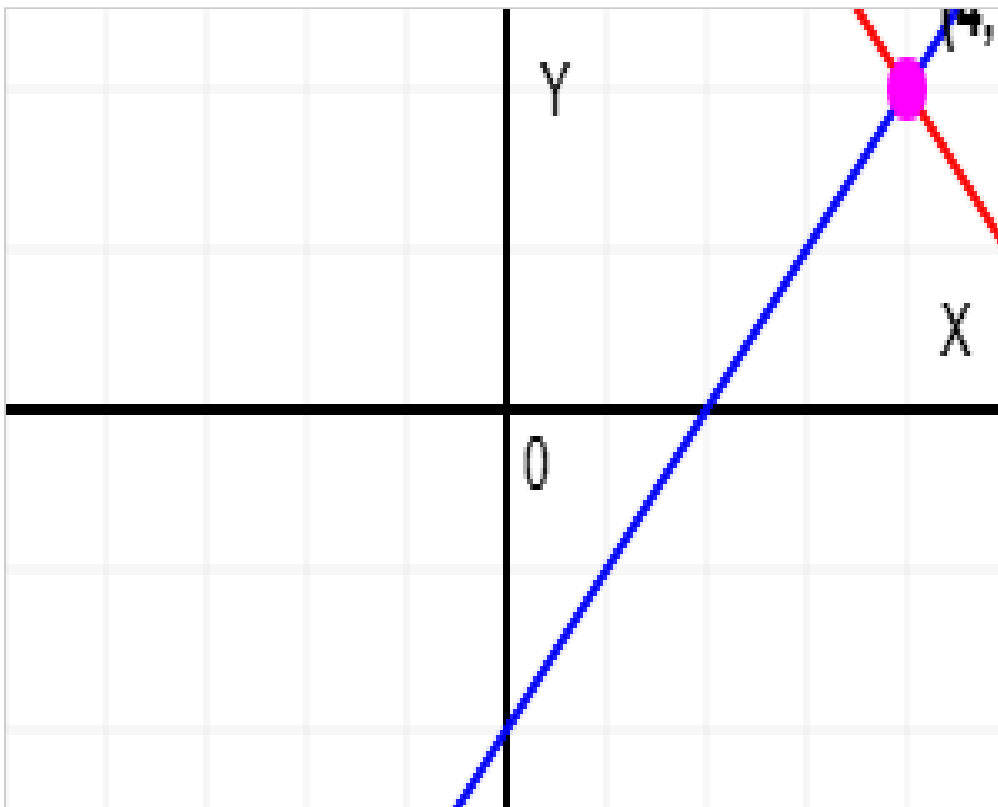


SECTION 2: GRAPHICAL REPRESENTATION

Understanding Through Graphs:

Case 1: Intersecting Lines (Unique Solution)

Example: $x + y = 6$ and $x - y = 2$



• **Solution Point:** (4, 2)

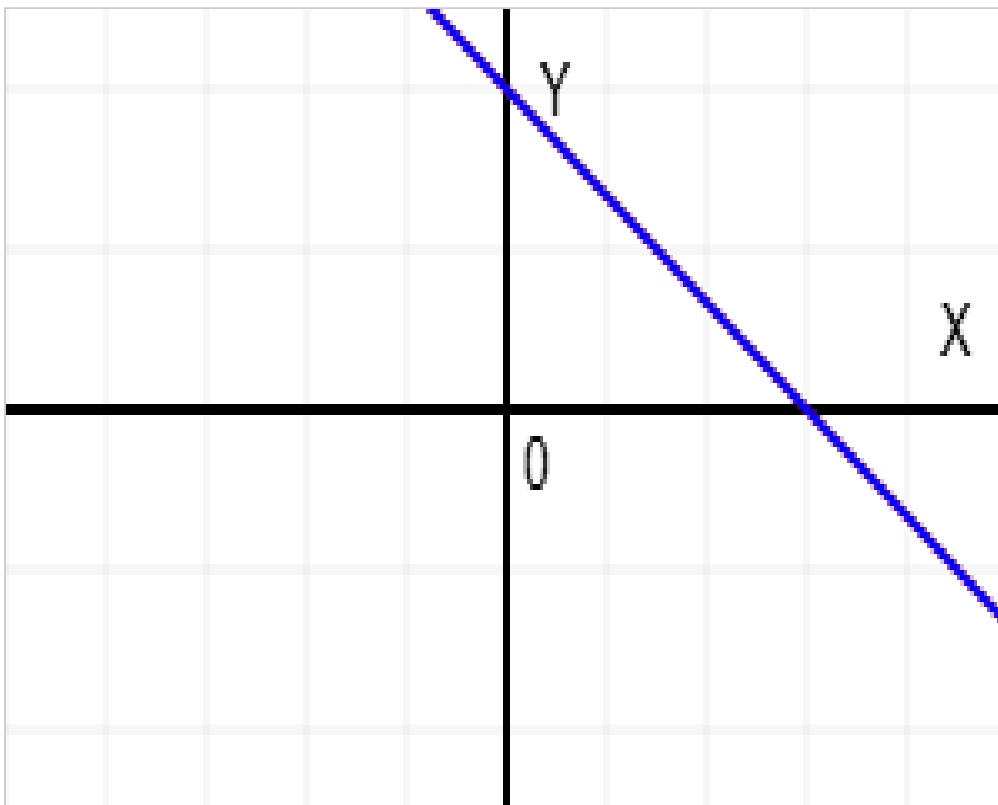
✓ Verification:

- Equation 1: $4 + 2 = 6$ ✓
- Equation 2: $4 - 2 = 2$ ✓

Conclusion: The lines intersect at ONE point, giving a UNIQUE solution.

Case 2: Coincident Lines (Infinitely Many Solutions)

Example: $2x + 3y = 6$ and $4x + 6y = 12$



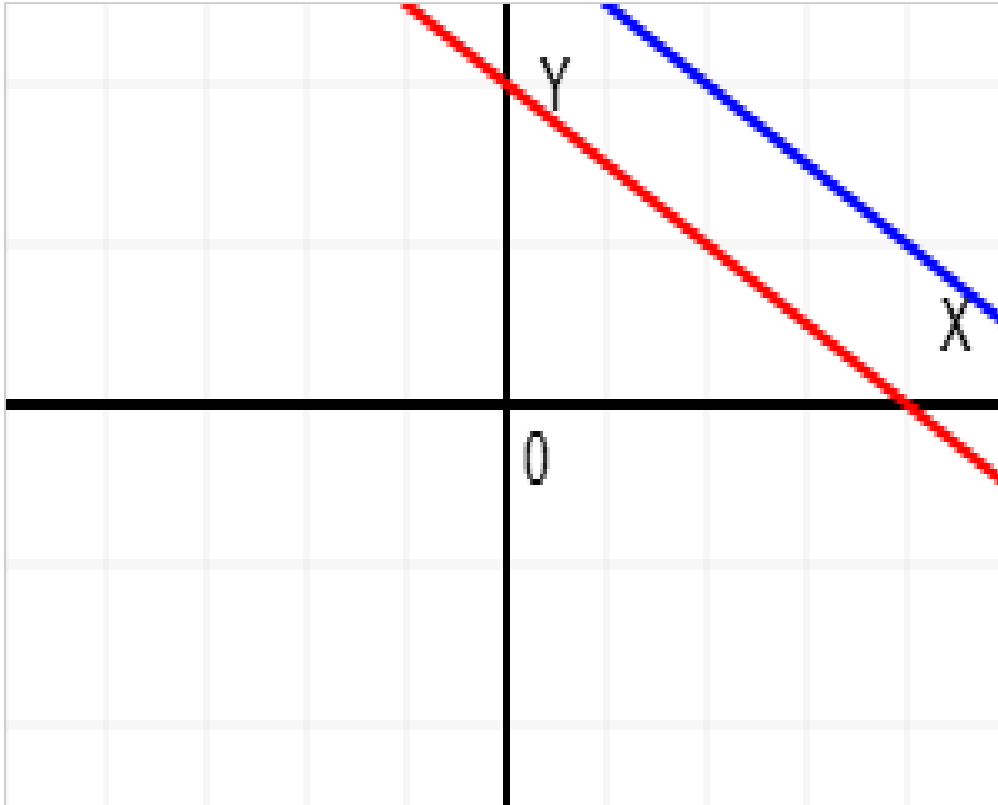
• **Solutions:** Infinitely many

Sample Points: (0, 2), (3, 0), (1.5, 1)

Conclusion: Both equations represent the SAME line. Every point on the line is a solution.

Case 3: Parallel Lines (No Solution)

Example: $x + 2y = 4$ and $2x + 4y = 12$



• **Solutions:** No solution

Conclusion: The lines are parallel and NEVER meet. The system is inconsistent.

Method 1: SUBSTITUTION METHOD**Steps:**

1. Express one variable in terms of the other from one equation
2. Substitute this value in the second equation
3. Solve for one variable
4. Substitute back to find the other variable

 **Example 1:**

Solve: $7x - 15y = 2$ and $x + 2y = 3$

Solution:

Step 1: From equation 2: $x = 3 - 2y$... (3)

Step 2: Substitute in equation 1:

$$7(3 - 2y) - 15y = 2$$

$$21 - 14y - 15y = 2$$

$$-29y = -19$$

$$y = 19/29$$

Step 3: Substitute y in equation (3):

$$x = 3 - 2(19/29) = 3 - 38/29 = 49/29$$

✓ Answer: $x = 49/29$, $y = 19/29$

Method 2: ELIMINATION METHOD

Steps:

1. Multiply equations to make coefficients of one variable equal
2. Add or subtract equations to eliminate that variable
3. Solve for the remaining variable
4. Substitute to find the other variable

Example 2:

Solve: $2x + 3y = 11$ and $3x + 2y = 9$

Solution:

Step 1: Multiply equation 1 by 3: $6x + 9y = 33$... (3)

Multiply equation 2 by 2: $6x + 4y = 18$... (4)

Step 2: Subtract (4) from (3):

$$(6x + 9y) - (6x + 4y) = 33 - 18$$

$$5y = 15$$

$$y = 3$$

Step 3: Substitute $y = 3$ in equation 1:

$$2x + 3(3) = 11$$

$$2x + 9 = 11$$

$$2x = 2$$

$$x = 1$$

✓ Answer: $x = 1, y = 3$

Method 3: CROSS-MULTIPLICATION METHOD

For equations: $a_1x + b_1y + c_1 = 0$ and $a_2x + b_2y + c_2 = 0$

$$x/(b_1c_2 - b_2c_1) = y/(c_1a_2 - c_2a_1) = 1/(a_1b_2 - a_2b_1)$$

a_1

b_1

c_1

a_2

b_2


c_2

How to Use Cross-Multiplication:

For Denominator (1): Multiply $a_1 \times b_2$ and $a_2 \times b_1$, then subtract: $(a_1b_2 - a_2b_1)$

For x Numerator: Multiply $b_1 \times c_2$ and $b_2 \times c_1$, then subtract: $(b_1c_2 - b_2c_1)$

For y Numerator: Multiply $c_1 \times a_2$ and $c_2 \times a_1$, then subtract: $(c_1a_2 - c_2a_1)$

 **Memory Tip:** Go in a circular pattern: $a_1 \rightarrow b_1 \rightarrow c_1$, then $a_2 \rightarrow b_2 \rightarrow c_2$, cross-multiply diagonally!

 **Example 3: Using Cross-Multiplication**

Solve: $2x + 3y - 7 = 0$ and $3x - y - 5 = 0$

Solution:

Here: $a_1 = 2$, $b_1 = 3$, $c_1 = -7$

$a_2 = 3$, $b_2 = -1$, $c_2 = -5$

Using formula:

$$x/(b_1c_2 - b_2c_1) = y/(c_1a_2 - c_2a_1) = 1/(a_1b_2 - a_2b_1)$$

Calculate each part:

$$b_1c_2 - b_2c_1 = 3 \times (-5) - (-1) \times (-7) = -15 - 7 = -22$$

$$c_1a_2 - c_2a_1 = (-7) \times 3 - (-5) \times 2 = -21 + 10 = -11$$

$$a_1b_2 - a_2b_1 = 2 \times (-1) - 3 \times 3 = -2 - 9 = -11$$

Therefore:

$$x/(-22) = y/(-11) = 1/(-11)$$

From $x/(-22) = 1/(-11)$:

$$-11x = -22$$

$$x = 2$$

From $y/(-11) = 1/(-11)$:

$$-11y = -11$$

$$y = 1$$

✓ Answer: $x = 2, y = 1$

Verification:

$$2(2) + 3(1) - 7 = 4 + 3 - 7 = 0 \checkmark$$

$$3(2) - 1 - 5 = 6 - 1 - 5 = 0 \checkmark$$

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💡 SECTION 4: TIPS & TRICKS

Quick Method Selection Guide:

When to Use	Method	Best For
One variable has coefficient 1	Substitution	$x = 3 - 2y$, $y = 5 - x$, etc.
Coefficients are easily made equal	Elimination	$2x + 3y = 5$, $3x + 2y = 5$
Complex fractions/decimals	Cross-Multiplication	Avoid calculation errors

⚠️ COMMON MISTAKES TO AVOID

- **✗ Sign Errors:** Forgetting to change signs when multiplying by negative numbers
- **✗ Wrong Substitution:** Substituting in the same equation instead of the other
- **✗ Calculation Mistakes:** Rushing through arithmetic operations
- **✗ Condition Check:** Forgetting to check consistency conditions (a_1/a_2 , b_1/b_2 , c_1/c_2)
- **✗ Not Verifying:** Skipping verification of answers in original equations

✓ SUCCESS TIPS

- **Always check:** a_1/a_2 , b_1/b_2 , c_1/c_2 ratios before solving
- **Choose wisely:** Pick the easiest method based on coefficients
- **Stay organized:** Number your equations and steps clearly
- **Verify always:** Substitute answers in both original equations

- **Practice graphs:** Visual understanding helps in exams

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SECTION 5: WORD PROBLEMS

Example 4: Age Problem

Problem: Five years ago, Nuri was thrice as old as Sonu. Ten years later, Nuri will be twice as old as Sonu. How old are Nuri and Sonu?

Solution:

Let Nuri's present age = x years

Let Sonu's present age = y years

Condition 1 (Five years ago):

$$x - 5 = 3(y - 5)$$

$$x - 5 = 3y - 15$$

$$x - 3y = -10 \dots (1)$$

Condition 2 (Ten years later):

$$x + 10 = 2(y + 10)$$

$$x + 10 = 2y + 20$$

$$x - 2y = 10 \dots (2)$$

Solving by Elimination:

Subtract (1) from (2):

$$(x - 2y) - (x - 3y) = 10 - (-10)$$

$$y = 20$$

Substitute $y = 20$ in equation (2):

$$x - 2(20) = 10$$

$$x = 50$$

✓ Answer: Nuri is 50 years old, Sonu is 20 years old

 **Example 5: Number Problem**

Problem: The sum of a two-digit number and the number obtained by reversing its digits is 66. If the digits differ by 2, find the number.

Solution:

Let ten's digit = x

Let unit's digit = y

Original number = $10x + y$

Reversed number = $10y + x$

Condition 1:

$$(10x + y) + (10y + x) = 66$$

$$11x + 11y = 66$$

$$x + y = 6 \dots (1)$$

Condition 2:

$$x - y = 2 \text{ or } y - x = 2$$

Case 1: If $x - y = 2 \dots (2)$

$$\text{Adding (1) and (2): } 2x = 8, \text{ so } x = 4, y = 2$$

$$\text{Number} = 42$$

Case 2: If $y - x = 2 \dots (3)$

$$\text{Adding (1) and (3): } 2y = 8, \text{ so } y = 4, x = 2$$

$$\text{Number} = 24$$

✓ Answer: The numbers are 42 and 24

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SECTION 6: PREVIOUS YEARS' BOARD QUESTIONS

 **Q1. [1 Mark - 2023]**

For what value of k will the equations $x + 2y = 5$ and $3x + ky - 15 = 0$ have infinitely many solutions?

Solution:

For infinitely many solutions:

$$a_1/a_2 = b_1/b_2 = c_1/c_2$$

$$1/3 = 2/k = -5/15$$

From $1/3 = 2/k$:

$$k = 6$$

✓ **Answer: $k = 6$**

 **Q2. [3 Marks - 2024]**

Solve: $2x + 3y = 11$ and $2x - 4y = -24$

Solution:

$$2x + 3y = 11 \dots (1)$$

$$2x - 4y = -24 \dots (2)$$

Subtract (2) from (1):

$$7y = 35$$

$$y = 5$$

Substitute $y = 5$ in equation (1):

$$2x + 3(5) = 11$$

$$2x + 15 = 11$$

$$2x = -4$$

$$x = -2$$

✓ **Answer: $x = -2, y = 5$**

 **Q3. [5 Marks - 2024]**

The coach of a cricket team buys 7 bats and 6 balls for ₹3800. Later, she buys 3 bats and 5 balls for ₹1750. Find the cost of each bat and each ball.

Solution:

Let cost of one bat = ₹ x

Let cost of one ball = ₹ y

$$7x + 6y = 3800 \dots (1)$$

$$3x + 5y = 1750 \dots (2)$$

$$\text{Multiply (1) by 3: } 21x + 18y = 11400 \dots (3)$$

$$\text{Multiply (2) by 7: } 21x + 35y = 12250 \dots (4)$$

Subtract (3) from (4):

$$17y = 850$$

$$y = 50$$

Substitute $y = 50$ in equation (2):

$$3x + 5(50) = 1750$$

$$3x + 250 = 1750$$

$$3x = 1500$$

$$x = 500$$

✓ **Answer: Cost of bat = ₹500, Cost of ball = ₹50**

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SECTION 7: IMPORTANT FORMULAS - QUICK REFERENCE

Consistency Conditions

Condition	Type	Solution
$a_1/a_2 \neq b_1/b_2$	Intersecting	Unique
$a_1/a_2 = b_1/b_2 = c_1/c_2$	Coincident	Infinite
$a_1/a_2 = b_1/b_2 \neq c_1/c_2$	Parallel	No solution

Cross-Multiplication Formula

$$x/(b_1c_2 - b_2c_1) = y/(c_1a_2 - c_2a_1) = 1/(a_1b_2 - a_2b_1)$$



SECTION 8: LAST MINUTE REVISION CHECKLIST

Theory to Remember:

- Definition of pair of linear equations
- Three types: Consistent (unique), Consistent (infinite), Inconsistent
- Graphical meaning: Intersecting, Coincident, Parallel lines
- Three algebraic methods: Substitution, Elimination, Cross-multiplication
- Consistency conditions: a_1/a_2 , b_1/b_2 , c_1/c_2 ratios

Methods to Master:

- Graphical method - plotting and finding intersection
- Substitution method - 4 steps
- Elimination method - 4 steps
- Cross-multiplication method - formula application
- Checking consistency before solving

Common Question Types:

- Find value of k for given condition
- Solve by any method and verify
- Word problems: Age, Numbers, Money, Distance-Speed-Time
- Graph interpretation - finding number of solutions

- Formation of equations from word problems

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MOTIVATIONAL MESSAGE

**"Mathematics is not about numbers, equations,
or algorithms.**

**It's about understanding patterns and solving
problems."**

Linear equations are everywhere around us! From calculating your phone's monthly bill to planning a road trip budget, from mixing ingredients in a recipe to designing bridges and buildings - linear equations help solve real-world problems!

Remember: Every mathematician, engineer, and scientist started exactly where you are. The difference between those who mastered math and those who struggled wasn't talent - it was consistent practice and never giving up.

Your Success Mantra:

- ✨ **Practice Daily:** Solve at least 5 problems every day using different methods
- ✨ **Master Graphs:** Visualize the lines - it makes understanding easier
- ✨ **Check Consistency:** Always check a_1/a_2 , b_1/b_2 , c_1/c_2 first
- ✨ **Learn from Mistakes:** Every wrong answer teaches you something new
- ✨ **Verify Answers:** Always substitute back in original equations

**"Success is the sum of small efforts repeated day in and day
out."**

**You've got this! Keep practicing, stay curious, and success will
follow.**

Team Math Love ❤️

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