Solving Linear Inequalities

Inequalities: Signed Operations and Solution Sets

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QUICK REVIEW

Solve inequalities using balanced operations, as with equations, but reverse the inequality when multiplying or dividing by a negative number. From $-2x < 6$, division gives $x > -3$. Strict symbols $<$ and $>$ exclude the endpoint; $\leq$ and $\geq$ include it. A solution set contains many possible values, so check both its direction and its boundary rather than naming just one example.

Worked example

Solve $-3x + 4 \leq 16$.

1. Subtract 4 from both sides: $-3x \leq 12$. The remaining variable coefficient is negative, so the final division must reverse the comparison.
2. Collect like terms while preserving order: $(-3 - 0)x \leq 16 - (4)$. This simplifies to $-3x \leq 12$.
3. Divide by -3: $x \geq -4$. Reverse the inequality when dividing by a negative number.
Answer: $x \geq -4$.

Practice Problems

Show your thinking.

1. Solve $2x + 3 < 11$.

2. Solve $5x - 7 \geq 18$.

3. Solve $-4x > 20$.

4. Solve $7 - 2x \leq 1$.

5. Solve $3(x - 2) < 12$.

6. Solve $-2(x + 1) \geq 8$.

7. Solve $4x + 1 < 2x + 9$.

8. Solve $\frac{x}{3} - 2 \geq 1$.

9. Which of $-2, 1, 4$ satisfy $3x - 1 \leq 5$? Show all three substitutions.

10. For $x > \frac{5}{2}$, is the endpoint included? Give one integer solution and one integer nonsolution.

Answer Key

1. $x < 4$.
2. $x \geq 5$.
3. $x < -5$.
4. $x \geq 3$.
5. $x < 6$.
6. $x \leq -5$.
7. $x < 4$.
8. $x \geq 9$.
9. -2 and 1 satisfy it; 4 does not.
10. Endpoint excluded; for example 3 works and 2 does not.

Step-by-Step Solutions

Follow each calculation, then check your own work.

Problem 1

1. Subtract 3 from both sides: $2x < 8$. This preserves the comparison because the same number is subtracted from each side.

2. Collect like terms while preserving order: $(2-0)x < 11-(3)$. This simplifies to $2x < 8$.

3. Divide by 2: $x < 4$. The positive divisor keeps the inequality direction unchanged.

Problem 2

1. Add 7 to both sides: $5x \geq 25$. The endpoint will remain included because the original comparison allows equality.

2. Collect like terms while preserving order: $(5-0)x \geq 18-(-7)$. This simplifies to $5x \geq 25$.

3. Divide by 5: $x \geq 5$. The positive divisor keeps the inequality direction unchanged.

Problem 3

1. Divide $-4x > 20$ by -4 and reverse the comparison: $x < -5$. The negative divisor changes the order.

2. Test the boundary $x = -5$: $-4(-5) = 20$, and $20 > 20$ is false. Therefore the endpoint is excluded.

3. Check either side: $-4(-6) = 24 > 20$ is true, but $-4(-4) = 16 > 20$ is false. Values left of -5 satisfy the inequality.

Problem 4

1. Subtract 7 from both sides to obtain $-2x \leq -6$. Both sides may be negative without changing the comparison at this subtraction step.

2. Collect like terms while preserving order: $(-2-0)x \leq 1-(7)$. This simplifies to $-2x \leq -6$.

3. Divide by -2: $x \geq 3$. Reverse the inequality when dividing by a negative number.

Problem 5

1. Distribute the positive factor: $3(x-2) = 3x-6$. The equivalent inequality is $3x-6 < 12$, before isolating the variable.

2. Collect like terms while preserving order: $(3-0)x < 12-(-6)$. This simplifies to $3x < 18$.

3. Divide by 3: $x < 6$. The positive divisor keeps the inequality direction unchanged.

Problem 6

1. Distribute carefully: $-2(x+1) = -2x-2$. Thus the inequality becomes $-2x-2 \geq 8$, with a negative variable coefficient.

2. Collect like terms while preserving order: $(-2-0)x \geq 8-(-2)$. This simplifies to $-2x \geq 10$.

3. Divide by -2: $x \leq -5$. Reverse the inequality when dividing by a negative number.

Problem 7

1. Subtract $2x$ from both sides: $2x+1 < 9$. Variable terms can be moved using subtraction without reversing the inequality.

2. Collect like terms while preserving order: $(4-2)x < 9-(1)$. This simplifies to $2x < 8$.

3. Divide by 2: $x < 4$. The positive divisor keeps the inequality direction unchanged.

Problem 8

1. The coefficient of x is $\frac{1}{3}$. Adding 2 to both sides gives $\frac{x}{3} \geq 3$, retaining the included endpoint.

2. Collect like terms while preserving order: $(\frac{1}{3}-0)x \geq 1-(-2)$. This simplifies to $\frac{1}{3}x \geq 3$.

3. Divide by $\frac{1}{3}$: $x \geq 9$. The positive divisor keeps the inequality direction unchanged.

Problem 9

1. At $x = -2$, calculate $3(-2)-1 = -7$. Since $-7 \leq 5$, the first proposed value satisfies the inequality.

2. At $x = 1$, calculate $3(1)-1 = 2$. Since $2 \leq 5$, this value also belongs to the solution set.

3. At $x = 4$, calculate $3(4)-1 = 11$. Since $11 \not\leq 5$, this value does not satisfy it. The accepted list is $-2, 1$.

Problem 10

1. The strict symbol $>$ excludes equality. Substitution of the endpoint would produce $\frac{5}{2} > \frac{5}{2}$, which is false.

2. The integer 3 satisfies $3 > 2.5$, so it is a solution. The integer 2 gives $2 > 2.5$, which is false.

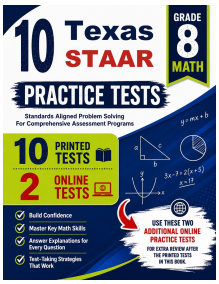
3. Thus the endpoint is excluded, with 3 as one integer solution and 2 as one integer nonsolution. Larger integers also satisfy the inequality.

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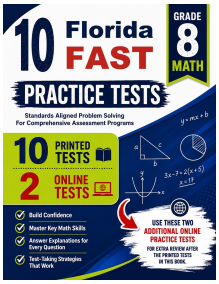
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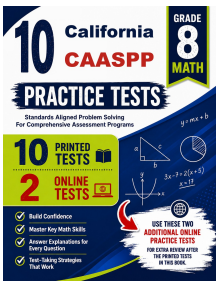
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