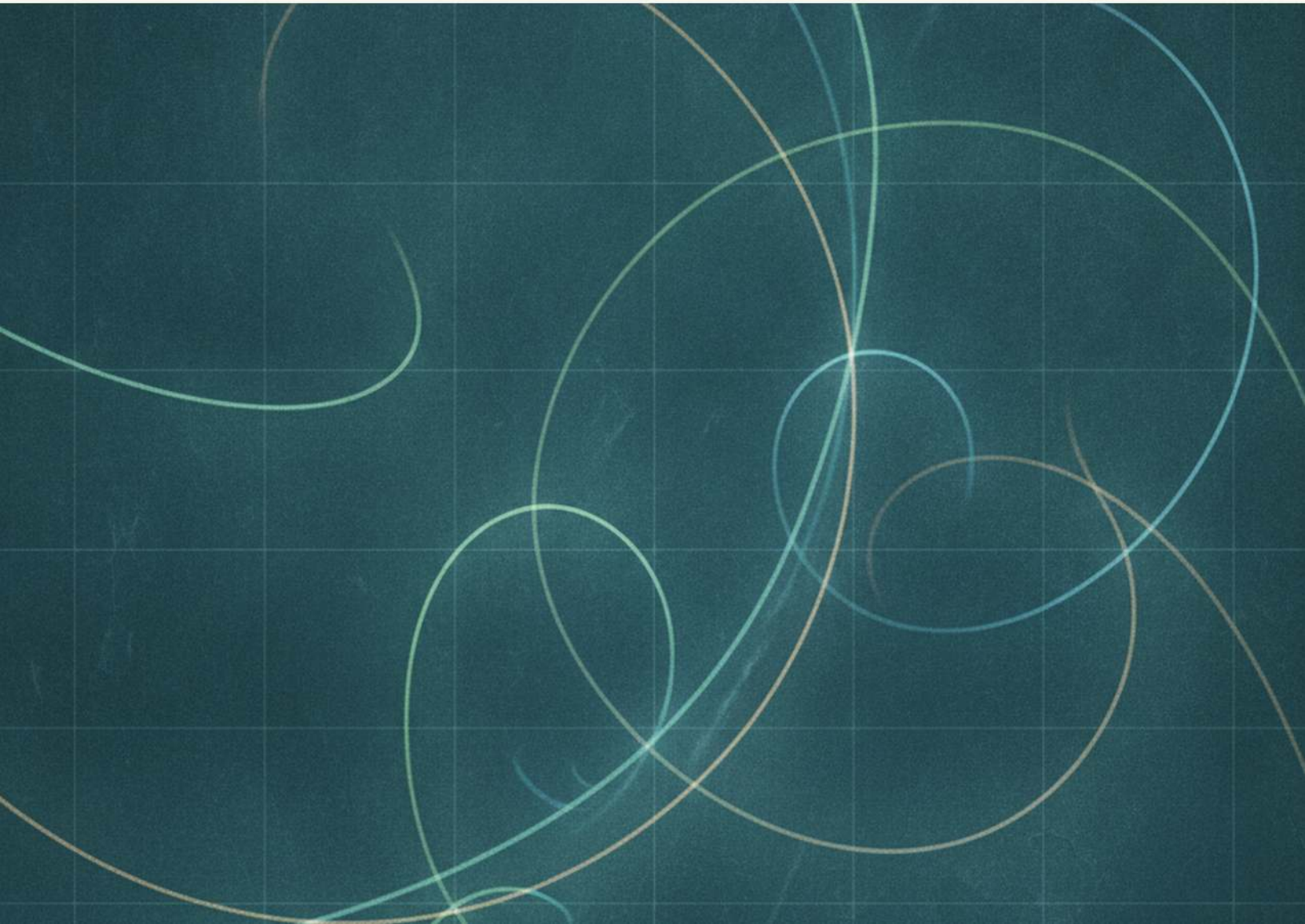
SAT MATH MASTERY

Algebra, Advanced Math & Desmos



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Chapter 2: Linear Equations, Inequalities, and Systems

Linear equations are the backbone of the Algebra domain, and they show up inside Advanced Math, data, and geometry questions too. If you are fast and accurate here, the rest of the section gets easier.

Solving linear equations in one variable

> **Key rule:** Whatever you do to one side of an equation, do to the other. Clear parentheses, collect the variable terms on one side, collect the numbers on the other, then divide.

Worked example. Solve $5(x - 2) - 3 = 2x + 8$.

Distribute: $5x - 10 - 3 = 2x + 8$, so $5x - 13 = 2x + 8$. Subtract $2x$ from both sides: $3x - 13 = 8$. Add 13: $3x = 21$. Divide by 3: $x = 7$.

Check by substituting: $5(7 - 2) - 3 = 25 - 3 = 22$, and $2(7) + 8 = 22$. Both sides match.

> **Trap:** Distributing to only the first term. $5(x - 2)$ is $5x - 10$, not $5x - 2$. This single slip produces a wrong answer that is almost always among the choices.

Fractions. When an equation has fractions, multiply every term by the least common denominator first. For $x/3 + x/4 = 14$, multiply by 12: $4x + 3x = 168$, so $7x = 168$ and $x = 24$.

No solution and infinitely many solutions. Some equations do not have exactly one solution. After simplifying, look at what is left.

- If the x terms cancel and you get a false statement such as $4 = 9$, there is **no solution**.
- If the x terms cancel and you get a true statement such as $4 = 4$, there are **infinitely many solutions**.
- If the x terms do not cancel, there is exactly **one solution**.

A faster way to see it: write each side in the form (coefficient)x + (constant). If the coefficients of x differ, there is one solution. If the coefficients match but the constants differ, there is no solution. If both match, there are infinitely many.

Worked example. For what value of c does $4(2x + 3) = 8x + c$ have infinitely many solutions?

The left side is 8x + 12. The coefficients of x already match (8 and 8), so the equation has infinitely many solutions exactly when the constants match: c = 12. For any other value of c, the equation has no solution.

Quick check: How many solutions does 3(x + 4) - x = 2(x + 5) have?

Answer: None. The left side is 2x + 12 and the right side is 2x + 10. Same coefficient, different constants.

Slope, intercepts, and the forms of a line

> **Key rule:** Slope is rise over run: m = (y2 - y1)/(x2 - x1). In y = mx + b, m is the slope and b is the y-intercept, the value of y when x = 0.

A line can be written in several forms. Each one makes something easy to read.

Form	Equation	Easy to read
Slope-intercept	y = mx + b	Slope m, y-intercept b
Point-slope	y - y1 = m(x - x1)	Slope m, a point (x1, y1)
Standard	Ax + By = C	Both intercepts: set x = 0 or y = 0

In standard form Ax + By = C, the slope is -A/B. You can get that by solving for y.

Worked example. A line passes through (-1, 4) and (3, -8). What is its equation?

Slope: (-8 - 4)/(3 - (-1)) = -12/4 = -3. Use point (-1, 4): 4 = -3(-1) + b, so 4 = 3 + b and b = 1. The line is y = -3x + 1.

Parallel and perpendicular lines. Parallel lines have equal slopes. Perpendicular lines have slopes that are negative reciprocals of each other: if one slope is 2/5, the perpendicular slope is -5/2. The product of perpendicular slopes is -1 (as long as neither line is vertical).

> **Trap:** Taking the reciprocal but forgetting the sign change, or changing the sign but forgetting the reciprocal. The perpendicular slope to 4 is -1/4, not 1/4 and not -4.

Intercepts from standard form. For 3x - 5y = 30, set y = 0 to get the x-intercept: 3x = 30, so x = 10. Set x = 0 to get the y-intercept: -5y = 30, so y = -6.

Quick check: What is the slope of a line perpendicular to 6x + 2y = 7?

Answer: 1/3. The given line has slope -6/2 = -3, and the negative reciprocal of -3 is 1/3.

Answer Explanations: Set A

1. **C.** Distribute: 4x - 12 + 7 = 2x + 15, so 4x - 5 = 2x + 15. Subtract 2x and add 5: 2x = 20, so x = 10. Check: 4(7) + 7 = 35 and 2(10) + 15 = 35. Choice A (5) comes from a sign slip that turns -12 + 7 into +5. Choice B (5.5) comes from distributing the 4 to x only, writing 4x - 3 + 7. Choice D (20) is the value of 2x; it stops one step early.
2. **B.** The $65 fee is charged once, so it is the constant. The $48 is charged for each hour, so it multiplies h: C = 48h + 65. Choice A swaps the roles of the fee and the hourly rate. Choice C adds the two numbers as if both were charged per hour. Choice D multiplies the fee by 48, which would charge the fee 48 times.
3. **1.** The slope is (19 - 7)/(6 - 2) = 12/4 = 3. Substitute (2, 7) into y = 3x + b: 7 = 6 + b, so b = 1. Acceptable entry: 1. A common error is using 7 as the intercept, but 7 is the y-value at x = 2, not at x = 0.
4. **D.** The term -35m means the amount in the tank goes down by 35 liters for each additional minute, so 35 is the number of liters drained per minute. Choice A describes 1,200, the value when m = 0. Choice B describes the solution to 1,200 - 35m = 0, which is about 34.3 minutes. Choice C describes 1,200 - 35 = 1,165, the amount after one minute.
5. **A.** Add the equations: 2x = 18, so x = 9. Then y = 14 - 9 = 5. Choice C (9) is the value of x, which is the trap of answering for the wrong variable. Choice B (7) is half of 14, as if x and y were equal. Choice D (10) is 14 - 4, which combines the constants without solving.
6. **25.** The expression 6x + 4y is exactly 2(3x + 2y) = 2(10) = 20. Adding 5 gives 25. Acceptable entry: 25. There is no need to find x or y; in fact, they cannot be found from one equation. This is a faster-by-hand question, since Desmos would show only a line of possible (x, y) pairs.
7. **B.** The inequality is 18 + 3.75n ≤ 50, so 3.75n ≤ 32 and n ≤ 8.53. Since she cannot buy part of a notebook, the greatest number is 8. Choice C (9) rounds 8.53 up, which would cost 18 + 33.75 = $51.75. Choice D (13) ignores the backpack and divides 50 by 3.75. Choice A (4) divides the backpack price by the notebook price, which has no meaning here.
8. **D.** Test (1, 1): 1 > 2(1) - 3 = -1 is true, and 1 ≤ -1 + 6 = 5 is true. Choice A fails the first inequality, since 4 > 5 is false. Choice B satisfies the first but fails the second, since 8 ≤ 7 is false. Choice C fails the first inequality, since 2 > 3 is false. In Desmos (Play 6), only (1, 1) lands in the overlap of the shaded regions.
9. **A.** A perpendicular line has slope -3/2, the negative reciprocal of 2/3. Substitute (6, 1): 1 = -(3/2)(6) + b = -9 + b, so b = 10. Choice B is parallel to the given line, not perpendicular. Choice C has the right slope but uses the y-value of the point as the intercept. Choice D