

DOK PROGRESSION GUIDE • SBAC MATHEMATICS

Math 3

Every SBAC claim and target for Math 3, with a Test Bank question at each Depth of Knowledge (DOK) level the blueprint assesses, and the clicks to find more.

DOK 1 Recall

DOK 2 Skills & concepts

DOK 3 Strategic thinking

DOK 4 Extended thinking

For Math 3 teachers. Claims, targets and DOK levels follow the official Smarter Balanced blueprint.

achievementtestbank.com • October 2026 edition

How to use this booklet

Depth of Knowledge (DOK) describes the kind of thinking a question asks for, not how hard it is. A long calculation can still be DOK 1, and a short question can be DOK 3. For each target, this booklet shows one question at every DOK level SBAC assesses it at, so you can see the climb and then pick questions at the level your students need next.

The four DOK levels

DOK 1 • Recall

Recall a fact, term or property, or carry out a routine one-step procedure. Read a value straight from a table or graph.

DOK 2 • Skills & concepts

Decide how to approach it and use two or more steps: compare, classify, interpret data, or move between representations.

DOK 3 • Strategic thinking

Reason and plan: justify an answer, critique an argument, use evidence, or solve a problem with no routine path.

DOK 4 • Extended thinking

Carry out an extended investigation that connects several ideas, conditions or sources. On SBAC, DOK 4 is assessed only in the performance task, and only for Claim 3 and Claim 4 targets.

Reading a target page

1. The heading names the claim, the target code and the official target wording, with the standards it draws on.
2. The DOK ladder shows which levels the SBAC blueprint assesses for this target in this grade. Levels in grey with a line through them are not assessed for this target.
3. One example question at each assessed level, lowest first, with the answer shown. Read them top to bottom to see how the thinking climbs.
4. "Why DOK n" explains in one sentence what makes the question that level, so you can spot the same thing in your own questions.
5. "Find more like this" lists the exact Test Bank clicks that generate more questions for the same target at the same level.

Which DOK levels each target is assessed at comes from the official Smarter Balanced test blueprint for this grade (2015–16 Summative Technical Report, Appendix 2.A). Every example was checked by hand against the DOK definitions above, not just its Test Bank tag. A few targets had no Test Bank question that truly fit a level, so we wrote one; those are marked "Written for this guide."

Finding these questions in the Test Bank

Every example page ends with the exact clicks. These are the two routes, starting from Create questions with Math 3 chosen as the course.

Claim 1 targets (CAT)

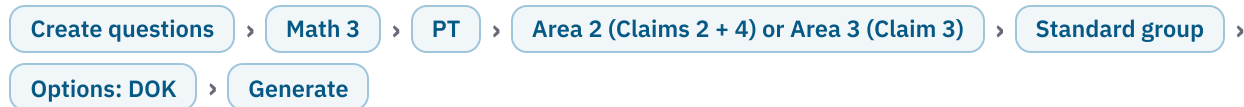
Claim 1 questions are filed by target and standard.



The DOK buttons only allow the levels the blueprint assesses for that target, so a level that is greyed out in this booklet is greyed out in the Test Bank too.

Claims 2, 3 and 4 (PT)

These claims are built from performance-task standard groups.



Each question card shows its claim and target, such as "Claim 3 · Tgt B". Generate at the DOK you want, then keep the cards for your target.

Questions you have saved

Saved questions are filed the same way in your Item Bank.



Tip: to move a class up the ladder, generate the same target at the next DOK level. To check that a skill is secure before going further, generate a set at the lowest assessed level.

All targets at a glance

A dot means the SBAC blueprint assesses the target at that DOK level in this grade. Each dot has an example question in this booklet.

Claim 1 • Concepts & Procedures

Target	DOK 1	DOK 2	DOK 3	DOK 4
1B Use properties of rational and irrational numbers	●	●	—	—
1D Interpret the structure of expressions	●	●	—	—
1E Write expressions in equivalent forms to solve problems	●	●	—	—
1F Perform arithmetic operations on polynomials	—	●	—	—
1G Create equations that describe numbers or relationships	●	●	—	—
1H Understand solving equations as a process of reasoning and explain the reasoning	●	●	—	—
1J Represent and solve equations and inequalities graphically	●	●	—	—
1L Interpret functions that arise in applications in terms of a context	●	●	—	—
1M Analyze functions using different representations	●	●	●	—
1N Build a function that models a relationship between two quantities	—	●	—	—
1P Summarize, represent, and interpret data on a single measurement variable	—	●	—	—

Claim 2 • Problem Solving

Target	DOK 1	DOK 2	DOK 3	DOK 4
2A Apply mathematics to solve well-posed problems from everyday life	—	●	●	—
2B Select and use appropriate tools strategically	●	●	●	—
2C Interpret results in the context of a situation	●	●	●	—
2D Identify important quantities in a practical situation and map their relationships (e.g., using diagrams, two-way tables, graphs, flow charts, or formulas)	●	●	●	—

Claim 3 • Communicating Reasoning

Target	DOK 1	DOK 2	DOK 3	DOK 4
3A Test propositions or conjectures with specific examples	—	●	●	—
3B Construct chains of reasoning that will justify or refute propositions	—	●	●	●
3C State logical assumptions being used	—	●	●	—
3D Use the technique of breaking an argument into cases	—	●	●	—
3E Distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in the argument—explain what it is	—	●	●	●
3F Base arguments on concrete referents such as objects, drawings, diagrams, and actions	—	●	●	—
3G Determine conditions under which an argument does and does not apply	—	●	●	—

Claim 4 • Modeling & Data Analysis

Target	DOK 1	DOK 2	DOK 3	DOK 4
4A Apply mathematics to solve problems from everyday life (Modeling)	—	●	●	—
4B Construct chains of reasoning to justify mathematical models	—	●	●	●
4C State logical assumptions being used	●	●	●	—
4D Interpret results in the context of a situation	—	●	●	—
4E Analyze adequacy and make improvements to existing models	—	●	●	●
4F Identify important quantities in a practical situation and map their relationships (e.g., using diagrams, two-way tables, graphs, flow charts, or formulas)	●	●	●	—
4G Identify, analyze, and synthesize relevant external resources to pose or solve problems	—	—	●	●

CLAIM 1

Claim 1 • Concepts & Procedures

Students can explain and apply mathematical concepts and interpret and carry out mathematical procedures with precision and fluency. Claim 1 is tested with individual items on the computer adaptive test (CAT). In the Test Bank, choose CAT, then the target.

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1B Use properties of rational and irrational numbers

Standards: N-CN.1; N-CN.2; N-CN.7

Assessed at: **DOK 1** **DOK 2** DOK 3 DOK 4**DOK 1 · Recall****Why DOK 1:** Students carry out one routine procedure, adding real parts and imaginary parts, with no decisions about strategy, so this is recall and reproduction.Which expression is equivalent to $(4 + 3i) + (2 - 5i)$?

☒ $6 - 2i$ ✓

☐ $6 + 8i$

☐ $2 + 8i$

☐ $4i$

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DOK 2 · Skills & concepts**Why DOK 2:** Students must choose a method, recognize a negative discriminant, and use $i^2 = -1$ to rewrite the square root, combining several steps.What are the solutions of $x^2 - 4x + 13 = 0$?

☒ $x = 2 \pm 3i$ ✓

☐ $x = -2 \pm 3i$

☐ $x = 2 \pm 3$

☐ $x = 4 \pm 6i$

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1D Interpret the structure of expressions

Standards: A-SSE.1; A-SSE.2

Assessed at:

DOK 1

DOK 2

DOK 3

DOK 4

DOK 1 • Recall

Why DOK 1: Students identify and factor out a greatest common factor, a single routine step that reveals the structure, so it is recall of a procedure.

A sports equipment company models the revenue from selling basketballs using the expression $\frac{48x^2-12x}{12x}$, where x represents the number of cases sold. Which of the following correctly identifies the structure of this expression by factoring out the greatest common factor from the numerator?

☐ $\frac{12(4x^2-x)}{12x} = \frac{4x^2-x}{x}$

☒ $\frac{12x(4x-1)}{12x} = 4x - 1$ ✓

☐ $\frac{48x(x-1)}{12x} = 4(x-1)$

☐ $\frac{6x(8x-2)}{12x} = \frac{8x-2}{2}$

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A-SSE.1

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Test Bank question

Why DOK 2: Students must factor, decide which parts can cancel, and judge the domain restriction for each statement, interpreting structure rather than just performing one step.

A sports analytics team is analyzing a quarterback's passing performance. The expression $\frac{3x^2+12x}{3x}$ represents the average yards gained per play across multiple games, where x represents the number of plays. Which of the following statements correctly interpret the structure of this expression? Select all that apply.

- ☐ The simplified form $x + 4$ is valid for all real values of x including $x = 0$.
- ☒ The coefficient 3 is a common factor of all terms in both the numerator and denominator. ✓
- ☐ The terms $3x^2$ and $12x$ in the numerator are like terms that combine to $15x^2$.
- ☒ The common factor $3x$ appears in both the numerator and denominator and can be canceled. ✓
- ☒ The numerator can be factored as $3x(x + 4)$, so the expression simplifies to $x + 4$ when $x \neq 0$. ✓

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Test Bank question

1E Write expressions in equivalent forms to solve problems

Standards: A-SSE.4

Assessed at: **DOK 1** **DOK 2** DOK 3 DOK 4**DOK 1 · Recall**

Why DOK 1: Students identify the first term, ratio, and number of terms and substitute directly into the geometric series formula, a routine application.

A basketball player practices free throws every day. On Day 1, she makes 2 shots. Each day after, she makes twice as many shots as the previous day. Using the formula for the sum of a finite geometric series, find the total number of shots she makes over the first 6 days. Write your answer as a whole number.

Correct answer: **126**

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Test Bank question

DOK 2 · Skills & concepts

Why DOK 2: Students must recognize the doubling pattern as a geometric series, set up the formula correctly, and explain why it applies, linking a context to a representation.

A sports team is selling raffle tickets to raise money for equipment. On the first day, they sell 100 tickets. Each day after, they sell twice as many tickets as the previous day. The team plans to sell tickets for 6 days total.

The sum of a finite geometric series with first term a , common ratio r (where $r \neq 1$), and n terms is:

$$S_n = a \cdot \frac{r^n - 1}{r - 1}$$

Part A: Using the geometric series formula, which expression correctly represents the total number of tickets sold over all 6 days?

Choose one answer.

☐ $100 \cdot \frac{6^2 - 1}{6 - 1} = 700$ tickets

☒ $100 \cdot \frac{2^6 - 1}{2 - 1} = 6300$ tickets ✓

☐ $6 \cdot (100 + 2) = 612$ tickets

☐ $100 \cdot \frac{2^6 - 1}{2} = 3150$ tickets

Part B: Which explanation best supports why the geometric series formula with $a = 100$, $r = 2$, and $n = 6$ is the correct approach for this problem?

Choose one answer.

- ☐ The formula applies because the team sells tickets on both odd and even days, making it geometric in nature.
- ☒ The daily ticket sales form a geometric sequence (100, 200, 400, 800, 1600, 3200) where each term is multiplied by the common ratio $r = 2$, and we need the sum of all 6 terms. ✓
- ☐ Since there are 6 days, we multiply 100 tickets by 6 to get the total regardless of how sales change each day.
- ☐ The total is found by adding 100 plus 6 days, so we use simple arithmetic instead of a formula.

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Test Bank question

1F Perform arithmetic operations on polynomials

Standards: A-APR.1; A-APR.2; A-APR.3; A-APR.4; A-APR.6

Assessed at: DOK 1 DOK 2 DOK 3 DOK 4

DOK 2 · Skills & concepts

Why DOK 2: Students divide a cubic, check the quotient and remainder, and verify a product, then judge several statements, which takes multiple connected steps.

A student divides $x^3 + 2x^2 - 5x - 6$ by $x - 2$ using polynomial long division. Decide whether each statement about this division is True or False.

	True	False
The quotient is $x^2 + 4x + 3$.	☒	☐
The remainder is 0.	☒	☐
$(x - 2)(x^2 + 4x + 3) = x^3 + 2x^2 - 5x - 6$.	☒	☐
The quotient is $x^2 + 4x - 3$.	☐	☒
The remainder is 5.	☐	☒

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Test Bank question

CLAIM 1 · CONCEPTS & PROCEDURES

1G Create equations that describe numbers or relationships

Standards: A-CED.1; A-CED.2; A-CED.3; A-CED.4

Assessed at: **DOK 1** **DOK 2** DOK 3 DOK 4

DOK 1 · Recall

Why DOK 1: Students rearrange a familiar formula with standard inverse operations to isolate one variable, a routine procedure with no modeling decisions.

The volume of a cylinder is $V = \pi r^2 h$. Which equation correctly solves this formula for r , where $r > 0$?

☒ $r = \sqrt{\frac{V}{\pi h}}$ ✓

☐ $r = \frac{V}{2\pi h}$

☐ $r = \sqrt{V - \pi h}$

☐ $r = \frac{\sqrt{V}}{\pi h}$

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DOK 2 · Skills & concepts

Why DOK 2: Students must translate a description into a cubic equation and then choose a way to solve it, which combines creating and solving in more than one step.

A shipping box has a square base. Its height is 3 inches more than the side length of the base, and its volume is 112 cubic inches. Write an equation for the volume in terms of the side length x , and solve it. What is the side length of the base, in inches?

Correct answer: **4**

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1H Understand solving equations as a process of reasoning and explain the reasoning

Standards: A-REI.2

Assessed at: **DOK 1** **DOK 2** DOK 3 DOK 4**DOK 1 · Recall**

Why DOK 1: Students square both sides of a simple radical equation and check the result, a routine procedure they recognize step by step.

A soccer coach is analyzing player performance using the equation $\sqrt{x - 5} = 3$, which models the relationship between training hours and goal-scoring improvement. Select all statements that correctly describe the solution process and the solution.

☐ We must check that $x = 14$ makes the original equation true because squaring both sides can introduce extraneous solutions ✓

☐ When we substitute $x = 14$ back into the original equation, we get $\sqrt{14 - 5} = \sqrt{9} = 3$, which is true ✓

☐ The solution is $x = 14$ ✓

☐ We do not need to check the solution because the equation has no radical sign in the final form

☐ To solve, square both sides of the equation to get $x - 5 = 9$ ✓

☐ The solution $x = 14$ is extraneous and should be rejected

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Test Bank question

Use the drop-down menus to complete the statement.

For $\sqrt{x - 5} = x - 7$, squaring gives candidate roots 6 and 9. At $x = 6$, the left side is



and the right side is



, so 6 is rejected. The valid solution is



.

Drop-down 1 choices: ✓

Drop-down 2 choices: ✓

Drop-down 3 choices: ✓

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Test Bank question

1J Represent and solve equations and inequalities graphically

Standards: A-REI.11

Assessed at:

DOK 1

DOK 2

DOK 3

DOK 4

DOK 1 · Recall

Why DOK 1: Students read directly from a table where two functions have equal outputs, which is recall of what a solution to $f(x) = g(x)$ means.

The table shows values of $f(x) = 2^x$ and $g(x) = x + 1$.

x : -1, 0, 1, 2, 3

$f(x)$: 0.5, 1, 2, 4, 8

$g(x)$: 0, 1, 2, 3, 4

Which values of x are solutions of the equation $2^x = x + 1$? Select all that apply.

☐ $x = -1$ ☒ $x = 0$ ✓☒ $x = 1$ ✓☐ $x = 2$ ☐ $x = 3$

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DOK 2 · Skills & concepts

Why DOK 2: Students must plan a successive-approximation strategy, evaluate both functions at several inputs, and interpret a sign change, which goes beyond reading a single value.

The graphs of $f(x) = 2^x$ and $g(x) = 7 - x$ intersect at exactly one point. Between which two values does the x -coordinate of the intersection point lie?

☐ between 2.0 and 2.1

☐ between 2.1 and 2.2

☒ between 2.2 and 2.3 ✓

☐ between 2.3 and 2.4

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1L Interpret functions that arise in applications in terms of a context

Standards: F-IF.4; F-IF.5; F-IF.6

Assessed at:

DOK 1

DOK 2

DOK 3

DOK 4

DOK 1 · Recall

Why DOK 1: Students identify the domain directly from the stated start and end times of the climb, recalling what a domain means in context.

A rock climber's height above ground during an ascent is modeled by the function $h(t) = \sqrt{t} + 2$, where h is height in meters and t is time in seconds. The climber starts at $t = 0$ and reaches the top of the wall at $t = 36$. Which statement correctly describes the domain of this function in the context of the climb?

- ☒ The domain is $0 \leq t \leq 36$ because the climber begins at $t = 0$ seconds and finishes at $t = 36$ seconds. ✓
- ☐ The domain is $t \geq 0$ because time cannot be negative.
- ☐ The domain is all real numbers because the square root function is defined for all real values.
- ☐ The domain is $2 \leq h \leq 8$ because those are the minimum and maximum heights reached.

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Test Bank question

The number of members in an online club is modeled by $M(t) = 500(1.2)^t$, where t is the number of years since the club started. What is the average rate of change of M from $t = 2$ to $t = 5$, and what does it mean?

- ☒ About 175 members per year; between years 2 and 5 the club gained about 175 members each year on average. ✓
- ☐ About 524 members per year; the club had about 524 more members in year 5 than in year 2.
- ☐ About 1.2 members per year; membership grows by a factor of 1.2 each year.
- ☐ About 415 members per year; this is the average number of members during years 2 through 5.

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CLAIM 1 · CONCEPTS & PROCEDURES

1M Analyze functions using different representations

Standards: F-IF.7; F-IF.8; F-IF.9; F-BF.3; F-BF.4a

Assessed at: **DOK 1** **DOK 2** **DOK 3** **DOK 4**

DOK 1 · Recall

Why DOK 1: Students recall that the constant added to a trigonometric function sets the midline and read it straight from the equation.

What is the midline of the graph of $y = 4 \cos\left(\frac{\pi}{6}x\right) + 10$?

☒ $y = 10$ ✓

☐ $y = 4$

☐ $y = 14$

☐ $y = 12$

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DOK 2 · Skills & concepts

Why DOK 2: Students connect the factored form to the graph, finding each zero and using multiplicity to decide whether the graph crosses, translating between representations.

For all real t , let $h(t) = -16t(t - 0.75)(t - 1.5)$. Which statement correctly describes the zeros and crossing behavior of this polynomial graph?

☐ Zeros 0.75 and 1.5 only; the factor t gives no zero.

☐ Zeros 0, 0.75 and 1.5; the graph only touches at all three zeros.

☒ Zeros 0, 0.75 and 1.5; the graph crosses at all three because each factor has multiplicity 1. ✓

☐ Zeros 0, 0.75 and 1.5; the graph only touches at 0.75 because it is a repeated root.

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students compare a table and an exponential equation, compute rates over intervals, and reason about long-run behavior to judge each claim, drawing conclusions from several sources.

Two youth sports leagues are tracking participant growth. League A's number of participants is given by the table below, where x is years since 2015. League B's number of participants is modeled by the exponential function $B(x) = 200(1.15)^x$.

x : 0, 1, 2, 3

League A participants: 200, 240, 280, 320

Decide whether each statement is True or False.

	True	False
Both League A and League B start with 200 participants when $x = 0$.	☒	☐
League A grows by a constant number of participants each year, while League B grows by a constant percentage each year.	☒	☐
At $x = 3$, League B has fewer participants than League A.	☒	☐
As x increases without bound, League A will always have more participants than League B.	☐	☒
The rate of change of League A from $x = 1$ to $x = 2$ (40 participants/year) is greater than the average rate of change of League B over the same interval.	☒	☐

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Test Bank question

CLAIM 1 · CONCEPTS & PROCEDURES

1N Build a function that models a relationship between two quantities

Standards: F-BF.1b; F-LE.4

Assessed at:

DOK 1

DOK 2

DOK 3

DOK 4

DOK 2 · Skills & concepts

Why DOK 2: Students substitute into a combined constant-plus-exponential model, isolate the exponential, and use a logarithm to solve, a multi-step process they must organize.

Soup begins at 180°F in a 75°F room. Its temperature is modeled by $T(t) = 75 + 105e^{kt}$. After 20 minutes the soup is 90°F. Find k using logarithms. Enter a number rounded to the nearest thousandth.

Correct answer: **-0.097**

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Test Bank question

CLAIM 1 • CONCEPTS & PROCEDURES

1P Summarize, represent, and interpret data on a single measurement variable

Standards: S-ID.4; S-IC.1; S-IC.2; S-IC.3–6; S-CP.1–5; S-CP.6–7

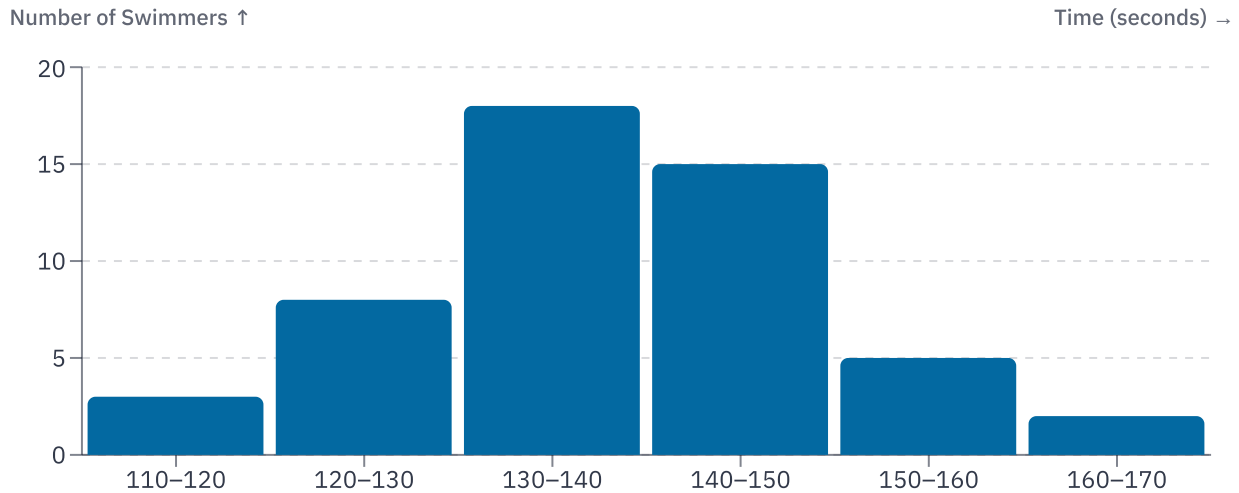
Assessed at: DOK 1 **DOK 2** DOK 3 DOK 4

DOK 2 • Skills & concepts

Why DOK 2: Students apply the empirical rule and compare it with a histogram to judge whether a normal model fits, interpreting data rather than just computing.

A coach analyzing 51 swimmers' times in the 200-yard freestyle finds that the mean time is **135** seconds and the standard deviation is approximately **12** seconds. The distribution appears approximately normal. Using the empirical rule (68-95-99.7), which statement best describes what this tells us about the swimmers' performance and the appropriateness of using a normal model?

Distribution of Swimming Times in 200-Yard Freestyle (High School Regional Championship)



- ☐ The mean of 135 seconds represents the time that exactly half the swimmers beat, and the standard deviation tells us the range of acceptable swimming times for the team.
- ☒ About 68% of swimmers finished between 123 and 147 seconds, which matches the histogram showing most swimmers in the 120–150 second range. The normal model is appropriate here because the data is roughly symmetric and unimodal. ✓
- ☐ Since the histogram shows a normal distribution, we can use it to predict that next year's swimmers will have identical mean and standard deviation, making a normal model always reliable for future predictions.



About 95% of swimmers finished between 111 and 159 seconds, so we can conclude that any time outside this range is an outlier that should be removed from the data.

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Test Bank question

CLAIM 2

Claim 2 • Problem Solving

Students can solve a range of complex well-posed problems in pure and applied mathematics, making productive use of knowledge and problem-solving strategies. In the Test Bank, Claims 2, 3 and 4 are built in the performance task (PT) step: choose PT, then Area 2 • Claims 2 + 4. Each question card is marked with its claim and target (for example "Claim 2 • Tgt A"), so generate a set at the DOK you want and keep the cards for the target you need.

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2A Apply mathematics to solve well-posed problems from everyday life

Assessed at: DOK 1 **DOK 2** DOK 3 DOK 4**DOK 2 • Skills & concepts**

Why DOK 2: Students must recognize a geometric series in an everyday situation, identify the first term, ratio, and number of terms, and then compute, which takes several decisions.

Maya starts a savings plan. She deposits \$50 in the first month, and each month after that she deposits 10% more than the month before. How much money will she have deposited in total after 12 months? Round to the nearest cent. (Ignore interest.)

Correct answer: **1069.21**

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DOK 3 · Strategic thinking

Why DOK 3: Students must plan a solution that uses two different series, compute and compare totals, and explain why the early-year comparison is misleading, which requires strategic reasoning.

Jordan has two job offers for the next 10 years.

Offer A: starting salary \$40,000, with a raise of \$2,000 every year.

Offer B: starting salary \$38,000, with a raise of 6% every year.

Which offer pays more in total over the 10 years, and by about how much? Show your work and explain how the year-by-year comparison differs from the 10-year total.

Model response: Offer A is an arithmetic series: $\text{total} = \frac{10}{2}(40,000 + 58,000) = 490,000$

Offer B is a geometric series: $\text{total} = \frac{38,000(1.06^{10} - 1)}{0.06} \approx 500,870$. Offer B pays about \$10,870 more over 10 years. Offer A pays more in the early years (for example, \$40,000 vs. \$38,000 in year 1), but Offer B's percent raises grow larger each year, so Offer B's yearly salary passes Offer A's (in year 6) and its later years more than make up the early difference.

Rubric: 1 point: Correct totals for both offers (about \$490,000 and about \$500,870), correct conclusion that Offer B pays about \$10,870 more, and an explanation that Offer A leads early but Offer B overtakes it.

0 points: Anything less, including a response that is only partly correct.

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2B Select and use appropriate tools strategicallyAssessed at: **DOK 1** **DOK 2** **DOK 3** ~~DOK 4~~**DOK 1 • Recall**

Why DOK 1: Students recall the change of base formula to use a calculator correctly, a single known procedure with no planning required.

Lena needs to evaluate $\log_3 20$. Her calculator has only LOG (base 10) and LN (base e) keys. Which expression could she enter to get the correct value?

☒ $\frac{\log 20}{\log 3}$ ✓

☐ $\frac{\log 3}{\log 20}$

☐ $\log \left(\frac{20}{3} \right)$

☐ $\log 20 - \log 3$

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DOK 2 · Skills & concepts

Why DOK 2: Students must evaluate several possible tools and decide which ones actually produce the needed precision, comparing approaches rather than carrying out one.

An investment of \$500 grows according to $A(t) = 500(1.04)^t$, where t is in years. Sam wants to find when the investment reaches 800, to the nearest tenth of a year. Which methods would give this answer? Select all that apply.

☐ Graph $y = 500(1.04)^x$ and $y = 800$ on a graphing calculator and find the x -coordinate of the intersection. ✓

☐ Rewrite as $1.04^t = 1.6$ and compute $t = \frac{\log 1.6}{\log 1.04}$ on a calculator. ✓

☐ Make a table of $A(t)$ for $t = 0, 1, 2, \dots$ and report the first whole number of years where $A(t) \geq 800$.

☐ Divide 800 by 500 and then divide by 0.04.

☐ Take the square root of both sides of $500(1.04)^t = 800$.

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DOK 3 · Strategic thinking

Why DOK 3: Students must recognize why an algebraic method fails, choose and justify a different tool, and verify their answer, which requires strategic planning.

A biologist models a fish population with $P(t) = 200(1.05)^t$ and the food supply (in fish that can be supported) with $F(t) = 300 + 12t$, where t is in years. She wants to know the first whole year in which the population exceeds the food supply.

- (a) Explain why solving $200(1.05)^t = 300 + 12t$ with logarithms alone will not isolate t .
(b) Choose a tool or method that will work, use it to answer the question, and justify your answer.

Model response: (a) The variable appears both in an exponent and in a linear term. Taking logarithms gives $\log 200 + t \log 1.05 = \log(300 + 12t)$, which still has t inside a logarithm, so it cannot be solved by algebra alone.

(b) Use a table or graph. $P(20) \approx 531 < F(20) = 540$, and $P(21) \approx 557 > F(21) = 552$. The population first exceeds the food supply in year 21. (A graphing calculator shows the intersection near $t \approx 20.6$.)

Rubric: 1 point: Correct explanation for (a), an appropriate tool for (b), and the correct answer (year 21) supported by values on both sides of the crossing.

0 points: Anything less, including a response that is only partly correct.

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2C Interpret results in the context of a situation

Assessed at: **DOK 1** **DOK 2** **DOK 3** ~~DOK 4~~

DOK 1 • Recall

Why DOK 1: Students directly interpret what an already-computed solution means in context, matching the variable and output to the situation.

A town's population is modeled by $P(t) = 12,000(0.92)^t$, where t is the number of years since 2020. Solving $P(t) = 6,000$ gives $t \approx 8.3$. What does this solution mean in this situation?

- ☒ About 8.3 years after 2020, the population is predicted to be half of its 2020 value. ✓
- ☐ The population decreases by about 8.3 people each year.
- ☐ The population decreases by 8.3% each year.
- ☐ In 2020 the population was about 8,300 people.

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A high school volleyball team's coach models the probability of winning a match using the function $P(x) = \frac{x}{x+5}$, where x represents the number of practice hours per week. The coach calculates that with 10 practice hours per week, the probability of winning is $P(10) = \frac{2}{3} \approx 0.667$. However, the team can only realistically commit to 10 hours per week due to academic schedules. Interpret what this result means for the team's season, discussing both the benefit of their practice commitment and any limitations of relying on this model to make decisions about their competitive prospects.

Model response: With 10 practice hours per week, the model predicts a 67% win probability, meaning the team should expect to win roughly 2 out of every 3 matches. This represents a meaningful competitive advantage since the probability exceeds 50%. However, the model has important limitations: it assumes practice hours are the only factor affecting wins, ignoring opponent strength, player talent variation, and game-day conditions. Additionally, the function shows diminishing returns—increasing to 15 hours would only raise the probability to 75%, so the team may face a practical ceiling on improvement. The coach should use this result as one input among others (such as scouting opponents and analyzing team weaknesses) rather than relying solely on practice volume to predict season success.

Rubric: 1 point: Interprets the probability result correctly in context ($\approx 67\%$ win rate), quantifies the benefit (winning about 2 of 3 matches), and identifies at least two limitations of the model (e.g., other variables ignored, diminishing returns, external factors) with discussion of implementation constraints. 0 points: Anything less, including a response that is only partly correct.

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must test each claim against the factored model, using sign analysis and end behavior, and decide which interpretations are supported, which requires reasoning with evidence.

A minor-league baseball team models its season profit (in thousands of dollars) as a function of ticket sales x (in thousands of tickets): $P(x) = x^3 - 13x^2 + 47x - 35$, which factors as $P(x) = (x - 1)(x - 5)(x - 7)$. Drag each statement into the box that correctly classifies it as a valid or invalid interpretation of the model.

Valid interpretation of the model

The team breaks even ($P(x) = 0$) when ticket sales are 1000, 5000, or 7000, since the factored form $(x - 1)(x - 5)(x - 7)$ equals zero exactly when one of those factors is zero. ✓

Testing the sign of each factor shows $P(x) > 0$ (profit) when $1 < x < 5$ or $x > 7$, but $P(x) < 0$ (a loss) when $5 < x < 7$ – so profit does not simply increase as more tickets are sold; there is a losing range even at moderate attendance. ✓

The constant term -35 in the expanded form is the value $P(0)$, meaning if zero tickets were sold the model predicts a loss of 35 thousand dollars, consistent with $(0 - 1)(0 - 5)(0 - 7) = -35$. ✓

Invalid or unsupported interpretation

Since the leading coefficient of the expanded form $x^3 - 13x^2 + 47x - 35$ is 1, profit grows without bound as ticket sales increase, so the team's maximum profit occurs at exactly 7000 tickets sold. ✓

Because the roots of $P(x)$ are 1, 5, and 7, the team's maximum profit equals the product $1 \times 5 \times 7 = 35$ thousand dollars, occurring when $x = 1 + 5 + 7 = 13$ thousand tickets are sold. ✓

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Test Bank question

2D Identify important quantities in a practical situation and map their relationships (e.g., using diagrams, two-way tables, graphs, flow charts, or formulas)

Assessed at: **DOK 1** **DOK 2** **DOK 3** ~~DOK 4~~**DOK 1 • Recall**

Why DOK 1: Students identify which quantities are relevant to the stated goal, a recognition task that needs no calculation or planning.

A coach is planning a training program for a basketball team. The team needs to track player performance over 12 weeks. The coach wants to measure improvement and set goals. Which of the following represent important quantities and their relationships that should be mapped out for this problem? Select all that apply.

- ☐ The color of each player's jersey and its effect on shooting accuracy
- ☐ The total cost of basketballs divided by the number of players on the team
- ☒ The number of free throws made per player per week and how this changes over the 12-week period ✓
- ☒ The number of minutes played per player per game as it relates to total points scored over 12 weeks ✓
- ☒ Each player's average points scored per game and the relationship between practice hours and points scored ✓
- ☐ The alphabetical order of players' last names

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Test Bank question

A high school lacrosse team's revenue model depends on ticket sales and concession sales. The total revenue function is $R(x) = 45x + 12x^2 - 0.5x^3$, where x represents the number of games played in a season. The team's total costs are represented by $C(x) = 200 + 8x$. To understand their profit dynamics, the team needs to identify key quantities and how they relate to each other. Which of the following correctly identify important quantities and their relationships in this profit system?

- ☐ The profit function is $P(x) = R(x) - C(x) = 45x + 12x^2 - 0.5x^3 - 200 - 8x$, which simplifies to $P(x) = 37x + 12x^2 - 0.5x^3 - 200$, showing how the different revenue and cost components combine to determine overall profitability. ✓
- ☐ The constant term 200 in the cost function represents fixed costs (like facility rental) that don't change with the number of games, while the term $8x$ represents variable costs that increase linearly with each game played. ✓
- ☐ The relationship between the number of games (x) and profit is linear because both revenue and cost functions involve the variable x .
- ☐ The $-0.5x^3$ term in revenue is a fixed cost that must be subtracted first before calculating variable costs.
- ☐ The term $12x^2$ in the revenue function represents a quadratic relationship where revenue increases at an increasing rate, but this relationship will eventually slow due to the $-0.5x^3$ term, which models market saturation or capacity constraints. ✓
- ☐ The coefficient 45 in the revenue function is independent of all other terms and can be analyzed separately without considering how it interacts with the $12x^2$ and $-0.5x^3$ terms.

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must identify the key quantities, organize them in a table, generalize the relationship as a series, and use it to justify a long-run conclusion.

A patient takes a 100 mg dose of a medicine every 12 hours. By the time of the next dose, 30% of the medicine in the body remains. The safe limit is 150 mg in the body at any time.

- (a) Make a table showing the amount of medicine in the body just after each of the first five doses.
- (b) Write an expression for the amount just after the n th dose.
- (c) Will the amount ever exceed the safe limit if the patient keeps taking the medicine? Justify your answer.

Model response: (a) Dose 1: 100; dose 2: $100 + 0.3(100) = 130$; dose 3: $100 + 0.3(130) = 139$; dose 4: 141.7; dose 5: 142.51 mg.

(b) $A_n = 100 + 100(0.3) + 100(0.3)^2 + \cdots + 100(0.3)^{n-1} = \frac{100(1 - 0.3^n)}{1 - 0.3}$.

(c) No. As n grows, 0.3^n approaches 0, so A_n approaches $\frac{100}{0.7} \approx 142.9$ mg and stays below that value. Since $142.9 < 150$, the amount never exceeds the safe limit.

Rubric: 1 point: Correct table, a correct expression (recursive or closed form), and a justified conclusion that the amount levels off near 142.9 mg and stays below 150 mg.

0 points: Anything less, including a response that is only partly correct.

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CLAIM 3

Claim 3 · Communicating Reasoning

Students can clearly and precisely construct viable arguments to support their own reasoning and to critique the reasoning of others. In the Test Bank, Claims 2, 3 and 4 are built in the performance task (PT) step: choose PT, then Area 3 · Claim 3. Each question card is marked with

its claim and target (for example "Claim 3 · Tgt A"), so generate a set at the DOK you want and keep the cards for the target you need.

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3A Test propositions or conjectures with specific examples

Assessed at: DOK 1 DOK 2 DOK 3 DOK 4

DOK 2 • Skills & concepts

Why DOK 2: Students rewrite the average expression and test specific values to find a counterexample, using examples to evaluate a conjecture.

A basketball coach models a player's scoring output using the polynomial function $S(g) = 2g^2 - 8g + 15$, where $S(g)$ represents total points scored and g is the number of games played. The coach conjectures that the player's scoring will always be at least 7 points per game when averaged over the season. To test this conjecture, we need to verify whether $\frac{S(g)}{g} \geq 7$ holds true for different values of g .

Part A: By rewriting the expression $\frac{S(g)}{g} = \frac{2g^2 - 8g + 15}{g}$ in simplified form, which of the following best represents the average points per game?

Choose one answer.

☐ $2g - 8g + 15$

☐ $g - 4 + \frac{15}{g}$

☐ $2g^2 - 8 + 15$

☒ $2g - 8 + \frac{15}{g}$



Part B: Testing the coach's conjecture that average scoring is always at least 7 points per game, which statement about specific values best supports that the conjecture is **false**?

Choose one answer.

☐ When $g = 1$: $2(1) - 8 + \frac{15}{1} = 2 - 8 + 15 = 9$ points per game, which is greater than 7, so the conjecture holds.

☐ When $g = 10$: $2(10) - 8 + \frac{15}{10} = 20 - 8 + 1.5 = 13.5$ points per game, which is greater than 7, so the conjecture holds.

☐ When $g = 3$: $2(3) - 8 + \frac{15}{3} = 6 - 8 + 5 = 3$ points per game, which is less than 7, but this is only one counterexample and does not disprove the overall pattern.

- ☐ When $g = 5$: $2(5) - 8 + \frac{15}{5} = 10 - 8 + 3 = 5$ points per game, which is less than 7, ✓ so the conjecture fails.

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students test several values, rewrite the rational expression to explain the trend, and judge whether the model is reasonable, building an argument from evidence.

A sports analyst proposes that a basketball player's scoring output can be modeled by the rational function $S(g) = \frac{24g+180}{g+12}$, where $S(g)$ represents average points per game and g represents the number of games played in a season. Test this conjecture by evaluating the function at specific games ($g = 5, 20, 50$) and interpreting what the behavior of this expression reveals about whether the model is reasonable for predicting a player's scoring trajectory. Explain your reasoning by identifying which part of the rational expression dominates at different values of g and what this means about the player's performance pattern.

Model response: At $g = 5$: $S(5) = \frac{24(5)+180}{5+12} = \frac{300}{17} \approx 17.6$ ppg. At $g = 20$: $S(20) = \frac{24(20)+180}{20+12} = \frac{660}{32} \approx 20.6$ ppg. At $g = 50$: $S(50) = \frac{24(50)+180}{50+12} = \frac{1380}{62} \approx 22.3$ ppg. By rewriting the expression as $S(g) = \frac{24g+180}{g+12} = 24 - \frac{108}{g+12}$ (using polynomial division), we see that as g increases, the fraction $\frac{108}{g+12}$ approaches zero, making $S(g)$ approach the horizontal asymptote of 24 ppg. This behavior is realistic: it shows the player's scoring gradually improves and stabilizes around 24 ppg, suggesting the model captures a learning/adaptation effect early in the season with diminishing improvement. The conjecture is reasonable because the asymptotic behavior matches realistic athlete performance patterns—initial growth that levels off.

Rubric: 1 point: Student evaluates at multiple points and notes increasing trend approaching a limit, but may not fully rewrite the expression or make complete connections to realistic patterns.

0 points: Anything less, including a response that is only partly correct.

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Test Bank question

3B Construct chains of reasoning that will justify or refute propositions

Assessed at: DOK 1 DOK 2 DOK 3 DOK 4 DOK 4 is assessed only in the performance task.

DOK 2 • Skills & concepts

Why DOK 2: Students set up and solve an equation to decide whether a value is ever reached, then choose the reasoning that justifies the claim, a short chain of logic.

A basketball player's scoring average follows the function $S(n) = \frac{420+18n}{n}$, where n is the number of games played and $S(n)$ is the average points per game. A coach claims that as the player participates in more games throughout the season, the scoring average will always approach 18 points per game but never actually reach it.

Part A: Is the coach's claim mathematically valid? Evaluate whether the scoring average can equal exactly 18 points per game for some finite value of n .

Choose one answer.

- ☒ Yes, the coach's claim is valid. The equation $\frac{420+18n}{n} = 18$ has no solution for any finite positive value of n . ✓
- ☐ No, the coach's claim is invalid because the average is already below 18 in the first game.
- ☐ No, the coach's claim is invalid. The scoring average equals exactly 18 when $n = 420$.
- ☐ Yes, the coach's claim is valid, but only because the player will never play infinitely many games.

Part B: Which mathematical reasoning best justifies your answer to Part A?

Choose one answer.

- ☒ When we solve $\frac{420+18n}{n} = 18$, we can multiply both sides by n to get $420 + 18n = 18n$, which simplifies to $420 = 0$. This is a contradiction, so no finite solution exists. ✓
- ☐ The horizontal asymptote of the function is $y = 18$, and horizontal asymptotes are never actually reached by the function for any real input value.
- ☐ The numerator $420 + 18n$ grows faster than the denominator n , so the fraction always increases and approaches infinity.

- ☐ Substituting $n = 1$ gives $\frac{438}{1} = 438$, which is much greater than 18, so the average cannot equal 18.

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must decide which steps form a rigorous justification, including a sign argument on an interval, which requires evaluating a complete chain of reasoning.

A sports statistician models a team's cumulative point-differential rating using the expression $E(x) = x^4 - 16x^2$, where x is the team's average scoring margin per game. The statistician claims: 'Because $E(x) = x^2(x - 4)(x + 4)$, the expression equals zero only when $x = -4$, $x = 0$, or $x = 4$, and $E(x)$ is negative for every x strictly between -4 and 4 except at $x = 0$.' Select all statements that are valid steps in a rigorous justification of this claim.

- ☐ Setting $E(x) = x^2(x - 4)(x + 4) = 0$ requires $x^2 = 0$ or $x - 4 = 0$ or $x + 4 = 0$, so the only solutions are $x = 0$, $x = 4$, and $x = -4$. ✓
- ☐ For any x with $-4 < x < 4$ and $x \neq 0$, the factor $(x - 4)$ is negative and $(x + 4)$ is positive, so their product is negative; since $x^2 > 0$ for these values, $E(x)$ must be negative there. ✓
- ☐ Since $x^2 \geq 0$ for every real number, $E(x)$ can never equal zero for any value of x .
- ☐ $x^4 - 16x^2$ can be rewritten by factoring out the common factor x^2 to get $x^2(x^2 - 16)$, and $x^2 - 16$ factors further as $(x - 4)(x + 4)$ using the difference of squares, giving $E(x) = x^2(x - 4)(x + 4)$. ✓
- ☐ Because the leading exponent in $x^4 - 16x^2$ is even, $E(x)$ must be nonnegative for every real value of x .
- ☐ Expanding $x^2(x - 4)(x + 4)$ gives $(x^2 - 16)^2$, so $E(x)$ is a perfect square and can never be negative.

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Test Bank question

DOK 4 · Extended thinking

Why DOK 4: Students carry out an extended investigation: they prove an identity, apply it to generate cases, test a general claim against a counterexample, and revise the method.

Investigation: Generating Pythagorean triples.

(a) Prove that $(x^2 + y^2)^2 = (x^2 - y^2)^2 + (2xy)^2$ for all real numbers x and y .

(b) Explain why, when x and y are positive integers with $x > y$, the numbers $x^2 - y^2$, $2xy$, and $x^2 + y^2$ always form a Pythagorean triple. Use the identity to generate the triples for $(x, y) = (2, 1)$, $(3, 2)$, and $(4, 1)$.

(c) A classmate claims the identity produces every Pythagorean triple. Test this claim using the triple 9, 12, 15. Can $x^2 + y^2 = 15$ for positive integers? What does this show about the claim, and how could the formula be modified so that it does produce 9, 12, 15?

Model response: (a) Left side: $x^4 + 2x^2y^2 + y^4$. Right side: $x^4 - 2x^2y^2 + y^4 + 4x^2y^2 = x^4 + 2x^2y^2 + y^4$. The two sides are equal, so the identity holds.

(b) If $x > y > 0$ are integers, then $x^2 - y^2$, $2xy$, and $x^2 + y^2$ are positive integers, and by (a) the square of the third equals the sum of the squares of the first two, so they form a right triangle's side lengths. $(2, 1)$: 3, 4, 5. $(3, 2)$: 5, 12, 13. $(4, 1)$: 15, 8, 17.

(c) The hypotenuse 15 would need $x^2 + y^2 = 15$. Checking $x = 1, 2, 3$ gives $15 - x^2 = 14, 11, 6$, none of which is a perfect square, so no positive integers work. The claim is false. However, $9, 12, 15 = 3(3, 4, 5)$, so multiplying all three expressions by a positive integer k , giving $k(x^2 - y^2)$, $2kxy$, $k(x^2 + y^2)$ with $k = 3, x = 2, y = 1$, produces it.

Rubric: 1 point: All parts addressed with one minor error or a missing justification.

0 points: Anything less, including a response that is only partly correct.

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3C State logical assumptions being used

Assessed at: DOK 1 **DOK 2** DOK 3 DOK 4**DOK 2 • Skills & concepts**

Why DOK 2: Students identify which facts the factoring argument depends on, including that a sum of squares has no real zeros, by connecting each step to the assumption it uses.

A sports analyst models the difference between two teams' squared season-scoring totals with the expression $S = x^4 - 81$, where x represents a scaled performance rating. The analyst factors it as $S = (x^2 - 9)(x^2 + 9) = (x - 3)(x + 3)(x^2 + 9)$ and concludes that the only real values of x making $S = 0$ are $x = 3$ and $x = -3$. Which logical assumptions are being used in this reasoning? Select all that apply.

- ☐ That $x^4 - 81$ can be viewed as a difference of two squares, $(x^2)^2 - (9)^2$, so the difference-of-squares pattern $a^2 - b^2 = (a - b)(a + b)$ applies with $a = x^2$ and $b = 9$. ✓
- ☐ That the variable x must always represent a positive score, since it appears in a sports context.
- ☐ That $x^2 + 9 = 0$ has no real solutions, so it contributes no additional real zeros beyond $x = 3$ and $x = -3$. ✓
- ☐ That $x^2 - 9$ itself fits the difference-of-squares pattern $a^2 - b^2 = (a - b)(a + b)$ with $a = x$ and $b = 3$, allowing further factoring into $(x - 3)(x + 3)$. ✓
- ☐ That factoring an expression is only valid when all exponents in the original expression are odd.
- ☐ That $x^2 + 9$ can be factored over the real numbers into two linear factors.

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Test Bank question

DOK 3 • Strategic thinking

Why DOK 3: Students must uncover a hidden assumption behind a broad conclusion drawn from a rational model and explain the consequence if it fails, reasoning beyond the math itself.

A basketball coach models a player's free throw success rate using the function $P(n) = \frac{100n}{n+50}$, where $P(n)$ is the percentage of successful free throws after n practice attempts. The coach claims that as the player practices more attempts (as $n \rightarrow \infty$), the success rate approaches 100%. The coach then uses

this model to conclude that with unlimited practice, any player can achieve near-perfect free throw accuracy, and therefore a player's natural talent is less important than practice volume.

Part A: Which of the following identifies a critical logical assumption embedded in the coach's mathematical argument about the limit behavior of $P(n)$?

Choose one answer.

- ☐ The maximum possible success rate is 100 percent.
- ☐ The number of practice attempts n must be a positive integer.
- ☒ The function $P(n) = \frac{100n}{n+50}$ accurately captures all factors affecting free throw performance, including physical fatigue, psychological pressure, and deteriorating technique over extended practice sessions. ✓
- ☐ The player must take at least 50 practice attempts before the model becomes valid.

Part B: Which statement best explains why this assumption is necessary for the coach's broader conclusion about talent versus practice, and what logical consequence follows if the assumption is violated?

Choose one answer.

- ☒ If the mathematical limit exists but the model omits significant real-world factors (like fatigue or psychological factors), then the theoretical limit of 100% may be unattainable in practice. This means the coach's conclusion that talent matters less than practice volume could be false—a player might plateau below 100% due to factors outside the model, suggesting natural limitations do matter. ✓
- ☐ The assumption ensures the model is continuous, which is required for all mathematical limits to exist and be meaningful.
- ☐ The assumption is not actually necessary because the limit $\lim_{n \rightarrow \infty} P(n) = 100$ is true regardless of what the model represents.
- ☐ Without this assumption, we cannot determine whether n should approach infinity or some other value.

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Test Bank question

3D Use the technique of breaking an argument into cases

Assessed at: DOK 1 DOK 2 DOK 3 DOK 4

DOK 2 • Skills & concepts

Why DOK 2: Students recognize which statements correctly use an even/odd case split and why the cases cover all integers, applying a given case structure.

A coach claims that for any integer number of total points n scored by a team over a season, the value $n^3 - n$ is always divisible by 6. A student rewrites the expression using its structure as $n^3 - n = (n - 1)n(n + 1)$ and proves the claim by breaking the argument into the cases ' n is even' and ' n is odd.' Select all statements that correctly describe valid reasoning used in this case-based proof.

- ☐ If n is even, n itself supplies a factor of 2; if n is odd, then both $n - 1$ and $n + 1$ are even, so one of them supplies a factor of 2. Either way the product is divisible by 2. ✓
- ☐ Testing the single value $n = 0$ shows the product equals 0, which is divisible by 6, so this one case proves the claim for all integers n .
- ☐ The two cases, n even and n odd, are exhaustive because every integer is either even or odd, so together the cases cover all possible values of n . ✓
- ☐ Because $(n - 1)n(n + 1)$ contains three factors, divisibility by 2 alone is enough to guarantee divisibility by 6, so checking factors of 3 is unnecessary.
- ☐ It is only necessary to check the case where n is even, since odd values of n will automatically behave the same way by symmetry.
- ☐ Since $(n - 1)n(n + 1)$ is a product of three consecutive integers, one of the three must be a multiple of 3, so the product is always divisible by 3, regardless of which case applies. ✓

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must plan the most efficient case split, deciding which divisibility needs cases and which does not, which is strategic reasoning about the proof itself.

Use the drop-down menus to complete the statement.

A league statistician defines the season-adjustment factor for n teams as $A(n) = n^3 - n$.

She wants to prove $A(n)$ is always divisible by 6 for every positive integer n , using the smallest possible number of cases. Rewriting the expression as $(n - 1)n(n + 1)$ ▾

shows $A(n)$ is the product of three consecutive integers. Since any two consecutive integers automatically include one even number, divisibility by 2 requires no case split. So

the most efficient case analysis needs only 3 ▾ cases, based on

the remainder when n is divided by 3 ▾, since that guarantees one of the three

consecutive integers is a multiple of 3 in every case.

Drop-down 1 choices: $n(n + 1)(n + 2)$ $(n - 1)(n + 1)$ $(n - 1)n(n + 1)$ ✓ $n^2(n - 1)$

Drop-down 2 choices: 2 3 ✓ 6

Drop-down 3 choices: whether n is greater than 3 the remainder when n is divided by 3 ✓
the remainder when n is divided by 2 whether n is even or odd only

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Test Bank question

3E Distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in the argument—explain what it is

Assessed at: DOK 1 DOK 2 DOK 3 DOK 4 DOK 4 is assessed only in the performance task.

DOK 2 • Skills & concepts

Why DOK 2: Students check each statement about rewriting expressions and classify it as correct or flawed, applying known rules to spot errors.

A sports analyst is examining polynomial expressions that model athlete performance metrics. She writes several expressions to represent different scenarios. Drag each expression or reasoning statement into the category that correctly describes it.

Correct reasoning about structure and rewriting

The expression $3x^2 + 6x$ can be rewritten as $3x(x + 2)$ by factoring out the GCF. ✓

In the expression $5(x^2 + 4x) + 2$, viewing $x^2 + 4x$ as a single entity helps identify that the expression equals $5x^2 + 20x + 2$. ✓

The expression $x^4 - 16$ can be rewritten as $(x^2 - 4)(x^2 + 4)$ by recognizing it as a difference of squares and applying the structure of that form. ✓

Flawed reasoning (logical error or unwarranted conclusion)

The expression $2x^3 - 8x^2 + 6x$ has three terms, so it cannot be factored. ✓

The expression $4x^3 + 12x^2 - 8x$ must equal zero because it has a common factor of $4x$. ✓

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students analyze four different arguments, decide which are valid, and name the type of error in each flawed one, critiquing reasoning with evidence.

A sports analyst studies the efficiency expression $E(x) = \frac{x^3 - 27}{x^2 - 9}$, where x is the number of games a player has played. Four students simplify this expression. Complete the table by identifying whether each student's reasoning is valid and, if not, the type of structural error made.

Student	Reasoning Shown	Valid?	Type of Error (if any)
A	"Cancel the x^2 term in the numerator and denominator: $\frac{x^3 - 27}{x^2 - 9} \rightarrow \frac{x - 27}{-9}$ "	no ▼	canceling terms instead of common factors ▼
B	"Factor numerator as a difference of cubes and denominator as a difference of squares: $\frac{(x - 3)(x^2 + 3x + 9)}{(x - 3)(x + 3)}$, then cancel the common factor $(x - 3)$ to get $\frac{x^2 + 3x + 9}{x + 3}$, valid for $x \neq 3, -3$ "	yes ▼	valid factorization, no error ▼
C	"Just cancel the constants -27 and -9 : $\frac{x^3 - 27}{x^2 - 9} \rightarrow \frac{x^3}{x^2} = x$ "	no ▼	canceling constants without factoring ▼
D	"Factor both correctly as $(x - 3)(x^2 + 3x + 9)$ and $(x - 3)(x + 3)$, then substitute $x = 3$ into the simplified form $\frac{x^2 + 3x + 9}{x + 3}$ to check, getting $\frac{27}{6} = 4.5$, matching the original limit as $x \rightarrow 3$ "	yes ▼	valid factorization, no error ▼

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Test Bank question

DOK 4 · Extended thinking

Why DOK 4: Students go beyond spotting the flaw: they investigate exactly when the faulty rule happens to work, derive a general condition, test it, and connect it to the correct property.

Riley claims that $\log(a + b) = \log a + \log b$ for all positive numbers a and b . As evidence, Riley shows that it works when $a = 2$ and $b = 2$: $\log 4 = \log 2 + \log 2$.

- (a) Explain the flaw in Riley's reasoning, and give a pair of positive numbers for which the equation is false.
- (b) Use the product property of logarithms to find the condition on a and b that makes $\log(a + b) = \log a + \log b$ true. Solve your condition for b in terms of a .
- (c) Use your result to find two more pairs that make the equation true, and state for which values of a a positive b exists.
- (d) Write a correct general property of logarithms that Riley may have been confusing with this one.

Model response: (a) One example cannot prove a statement for all values. For $a = 1$, $b = 1$: $\log 2 \approx 0.301$, but $\log 1 + \log 1 = 0$, so the claim is false.

(b) $\log a + \log b = \log(ab)$, so the equation holds exactly when $\log(a + b) = \log(ab)$, that is, when $a + b = ab$. Solving: $ab - b = a$, so $b(a - 1) = a$ and $b = \frac{a}{a - 1}$.

(c) $a = 3$ gives $b = 1.5$ (check: $\log 4.5 = \log 3 + \log 1.5$). $a = 5$ gives $b = 1.25$. A positive b exists only when $a > 1$.

(d) $\log(ab) = \log a + \log b$.

Rubric: 1 point: Three parts fully correct.

0 points: Anything less, including a response that is only partly correct.

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3F Base arguments on concrete referents such as objects, drawings, diagrams, and actions

Assessed at: DOK 1 **DOK 2** DOK 3 DOK 4

DOK 2 • Skills & concepts

Why DOK 2: Students must connect a physical shading model to a geometric series and use the picture, not just a formula, to explain the sum.

A square sheet of paper has an area of 1 square unit. Step 1: shade half of the sheet. Step 2: shade half of the unshaded part. Each step shades half of what is still unshaded. After 5 steps, the shaded area is $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32}$. Which statement uses the paper model correctly to find this sum?

- ☒ The unshaded piece left after 5 steps has area $\frac{1}{32}$, so the shaded area is $1 - \frac{1}{32} = \frac{31}{32}$. ✓
- ☐ Each step shades $\frac{1}{2}$ of the sheet, so after 5 steps the shaded area is $5 \cdot \frac{1}{2} = \frac{5}{2}$.
- ☐ The last piece shaded has area $\frac{1}{32}$, so the total shaded area is $\frac{1}{32}$.
- ☐ The pieces get smaller, so the shaded area after 5 steps is less than $\frac{1}{2}$.

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DOK 3 · Strategic thinking

Why DOK 3: Students must build a general argument from a diagram, using symmetry of the unit circle as evidence instead of checking one angle, which is strategic reasoning.

A student claims that $\sin(180^\circ - \theta) = \sin \theta$ for every angle θ . Use a unit circle diagram to construct an argument that justifies or refutes the claim. In your argument, describe the location of the points for θ and $180^\circ - \theta$ on the unit circle, explain how they are related, and state what your diagram shows about $\cos(180^\circ - \theta)$ as well.

Model response: On the unit circle, the angle θ ends at the point $P = (\cos \theta, \sin \theta)$. The angle $180^\circ - \theta$ is measured the same amount back from the negative x -axis, so its terminal point Q is the reflection of P across the y -axis: $Q = (-\cos \theta, \sin \theta)$. Reflection across the y -axis keeps the y -coordinate and changes the sign of the x -coordinate. Since sine is the y -coordinate, $\sin(180^\circ - \theta) = \sin \theta$, so the claim is true. The diagram also shows $\cos(180^\circ - \theta) = -\cos \theta$. (Example check: $\sin 150^\circ = \sin 30^\circ = 0.5$.)

Rubric: 1 point: A correct diagram or description showing the two terminal points as reflections across the y -axis, a clear explanation that the y -coordinates (sines) are equal, and the correct conclusion about cosine.

0 points: Anything less, including a response that is only partly correct.

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3G Determine conditions under which an argument does and does not apply

 Assessed at: DOK 1 **DOK 2** DOK 3 DOK 4
DOK 2 • Skills & concepts

Why DOK 2: Students evaluate the argument at several values and find the case where a factor equals 1, identifying where the argument stops applying.

A coder claims: 'For every whole number n greater than or equal to 2, the expression n^3-1 factors as $(n-1)(n^2+n+1)$. Since both factors are whole numbers greater than 1, n^3-1 is never a prime number.'

Complete the table to check this claim for app-update counts $n = 2, 3, 4$, and 5, then decide where the claim does and does not hold.

n	$n-1$	n^2+n+1	n^3-1	Is n^3-1 prime?
2	1	7	7	yes ▼
3	2	13	26	no ▼
4	3	21	63	no ▼
5	4	31	124	no

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must decide exactly when a factoring method yields integer coefficients and why a sum of squares does not factor, generalizing the conditions for the argument.

A game designer is studying the expression $n^4 - 81$, where n is the number of levels unlocked. A student argues: 'Since $n^4 - 81$ is a difference of squares, it factors as $(n^2 - 9)(n^2 + 9)$, and any expression of the form $n^4 - c$ can be factored this way using $(n^2 - \sqrt{c})(n^2 + \sqrt{c})$.' Decide whether each statement about this argument is true or false.

	True	False
$(n^2 - 9)(n^2 + 9)$ is a correct difference-of-squares factorization of $n^4 - 81$.	☒	☐
The complete factorization of $n^4 - 81$ over the integers is $(n - 3)(n + 3)(n^2 + 9)$, since $n^2 - 9$ is itself a difference of squares.	☒	☐
Applying the same method to $n^4 - 80$ gives a factorization $(n^2 - \sqrt{80})(n^2 + \sqrt{80})$ with all integer coefficients.	☐	☒
The pattern $(n^2 - \sqrt{c})(n^2 + \sqrt{c})$ works algebraically for any $c \geq 0$, but it only produces integer coefficients when c is a perfect square.	☒	☐
The factor $n^2 + 9$ can be broken into two real linear factors, just like $n^2 - 9$ can.	☐	☒

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Test Bank question

CLAIM 4

Claim 4 • Modeling & Data Analysis

Students can analyze complex, real-world scenarios and can construct and use mathematical models to interpret and solve problems. In the Test Bank, Claims 2, 3 and 4 are built in the performance task (PT) step: choose PT, then Area 2 • Claims 2 + 4. Each question card is marked with its claim and target (for example "Claim 4 • Tgt A"), so generate a set at the DOK you want and keep the cards for the target you need.

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4A Apply mathematics to solve problems from everyday life (Modeling)

Assessed at: DOK 1 **DOK 2** DOK 3 DOK 4

DOK 2 • Skills & concepts

Why DOK 2: Students build the average cost expression from the total cost model and interpret how each term behaves, connecting the model to the situation in two steps.

A school is ordering new band uniforms. The cost to manufacture x uniforms is given by $C(x) = 500 + 8x + 0.02x^2$, where cost is in dollars. Here, 500 is the fixed setup cost, $8x$ is the per-uniform labor cost, and $0.02x^2$ is extra material cost from bulk ordering. The team divides the whole expression by x to find the average cost per uniform. Which expression correctly shows the average cost, and what happens to it as more uniforms are ordered?

- ☐ Average cost = $\frac{500+8x}{0.02x^2}$; the average cost stays dominated by material costs no matter how many uniforms are ordered.
- ☒ Average cost = $\frac{500}{x} + 8 + 0.02x$; it first decreases as fixed cost spreads out, then increases as material costs grow. ✓
- ☐ Average cost = $\frac{500}{x} + 8 + 0.02$; the average cost settles near 8 dollars per uniform as orders grow large.
- ☐ Average cost = $500 + 8 + 0.02x$; the average cost increases in a straight line as more uniforms are ordered.

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must create a model from a physical situation, restrict its domain, and plan a systematic search to meet a requirement and optimize, which needs strategic thinking.

A company makes open-top boxes from rectangular sheets of cardboard that measure 20 cm by 30 cm. A square with side length x cm is cut from each corner, and the sides are folded up.

- (a) Write a function $V(x)$ for the volume of the box and state a reasonable domain.
- (b) The company wants boxes that hold at least 1000 cubic centimeters, and it will only cut whole-centimeter squares. Which cut sizes meet this requirement?
- (c) Which of these cut sizes gives the greatest volume? Justify your answer.

Model response: (a) $V(x) = x(30 - 2x)(20 - 2x)$, with $0 < x < 10$ because the 20 cm side must stay positive.

(b) $V(1) = 504$, $V(2) = 832$, $V(3) = 3(24)(14) = 1008$, $V(4) = 4(22)(12) = 1056$, $V(5) = 5(20)(10) = 1000$, $V(6) = 864$, and the volumes keep decreasing up to $x = 9$. The cuts that work are 3 cm, 4 cm, and 5 cm.

(c) A 4 cm cut gives the greatest volume, 1056 cubic centimeters, which is larger than the volumes for 3 cm and 5 cm.

Rubric: 1 point: Correct volume function and domain, the correct set of cut sizes $\{3, 4, 5\}$ supported by computed volumes, and the correct choice of 4 cm with justification.

0 points: Anything less, including a response that is only partly correct.

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4B Construct chains of reasoning to justify mathematical models

Assessed at: DOK 1 DOK 2 DOK 3 DOK 4 DOK 4 is assessed only in the performance task.

DOK 2 • Skills & concepts

Why DOK 2: Students compare the shape of the data with the behavior of different function families to justify which model fits, interpreting features rather than recalling them.

A coach is modeling the relationship between a basketball player's free throw attempts per practice and her free throw percentage over a season. The coach collects data showing that as the number of attempts increases from 10 to 50 per practice, the free throw percentage increases from 60% to 82%, then levels off around 85% as attempts approach 100 per practice. Which statements justify why a quadratic model would NOT be appropriate for this situation, and which justify why a different model might be better?

- ☐ Linear models are never used in sports, so a quadratic model must be the correct choice.
- ☐ A rational function or exponential decay model better captures the assumption that performance improvements follow a learning curve where initial gains are larger but progress slows as the player approaches her skill ceiling. ✓
- ☐ A quadratic model could show the leveling off pattern in the data because parabolas have both increasing and decreasing sections.
- ☐ The data shows growth that slows down and approaches a limit, which indicates a horizontal asymptote—a characteristic of exponential decay or rational functions, not quadratic functions. ✓
- ☐ A quadratic model would eventually predict decreasing percentages at high practice levels, but the data shows the percentage stabilizes near 85%, contradicting what a parabola would predict. ✓
- ☐ The coach should use a quadratic model because the relationship involves two variables: attempts and percentage.

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Test Bank question

A gardener hangs a plant pot from a chain and studies how the chain length L (in meters) affects the time T (in seconds) for one full swing, shown in the table above. Four models are proposed:

Model 1: $T = \frac{2}{3}L$

Model 2: $T = 2L^{1/2}$

Model 3: $T = 0.03L^2$

Model 4: $T = 2(1.15)^L$

Which model correctly fits ALL four data points, and why does it make the best structural sense compared to the others?

Hanging Plant Swing: Chain Length vs. Swing Time

Chain Length L (meters)	Swing Time T (seconds)
$L = 1$	2
$L = 4$	4
$L = 9$	6
$L = 16$	8

- ☐ Model 3, because squaring L eventually produces numbers close to the larger T values, so a quadratic function best matches the overall trend
- ☐ Model 1, because T seems to increase by the same fixed amount each time L increases by 3, matching the constant additive change of a linear function
- ☐ Model 4, because T seems to grow faster than a straight line as L increases, which matches the fast-growing pattern of an exponential function
- ☒ Model 2, because $T \div L^{1/2}$ equals 2 for every point, and only a square-root relationship turns the unevenly spaced L -values into these evenly spaced T -values ✓

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DOK 4 · Extended thinking

Why DOK 4: Students conduct an extended modeling task: they reject one model with evidence, transform data to discover a structure, build and test a new model, and justify its long-run behavior.

A cup of tea is left in a room that is 20°C . Its temperature is measured every 10 minutes.

Time t (minutes): 0, 10, 20, 30, 40

Temperature ($^{\circ}\text{C}$): 90, 62, 45, 35, 29

- A student proposes the linear model $T = 90 - 2.8t$. Use the data and the situation to explain why this model is not appropriate.
- Compute $T - 20$ for each data point and use the results to justify a model of the form $T(t) = 20 + C \cdot b^{t/10}$.
- Find C and b from the data, and test your model against the remaining data points.
- Use your model to predict the temperature after 60 minutes and after a very long time. Explain why these predictions make sense in the situation.

Model response: (a) The linear model fits the first two points but predicts 34°C at 20 minutes (actual 45) and -22°C at 40 minutes, below room temperature, which is impossible. The data cool quickly at first and then more slowly.

(b) $T - 20$: 70, 42, 25, 15, 9. Successive ratios are about 0.6 ($42/70 = 0.6$, $25/42 \approx 0.60$, $15/25 = 0.6$, $9/15 = 0.6$), so the difference from room temperature decreases by a constant factor every 10 minutes, which is exponential decay toward 20.

(c) $C = 70$ (at $t = 0$) and $b = 0.6$, so $T(t) = 20 + 70(0.6)^{t/10}$. Predictions: $t = 20$: 45.2; $t = 30$: 35.1; $t = 40$: 29.1, all within 0.2°C of the data.

(d) $T(60) = 20 + 70(0.6)^6 \approx 23.3^{\circ}\text{C}$. As t grows, $(0.6)^{t/10}$ approaches 0, so T approaches 20°C . This makes sense because the tea cools toward room temperature but never goes below it.

Rubric: 1 point: Correct model and predictions with one weak justification.

0 points: Anything less, including a response that is only partly correct.

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4C State logical assumptions being used

Assessed at: **DOK 1** **DOK 2** **DOK 3** DOK 4**DOK 1 • Recall****Why DOK 1:** Students recognize two basic assumptions built into the model, the limiting value and a nonnegative input, directly from its form and context.

Use the drop-down menus to complete the statement about the model.

A coach models a basketball player's free-throw success rate using the rational function

 $f(x) = \frac{50x+100}{x+3}$, where x represents the number of practice sessions. The model assumesthat , and italso assumes that .**Drop-down 1 choices:** **Drop-down 2 choices:**

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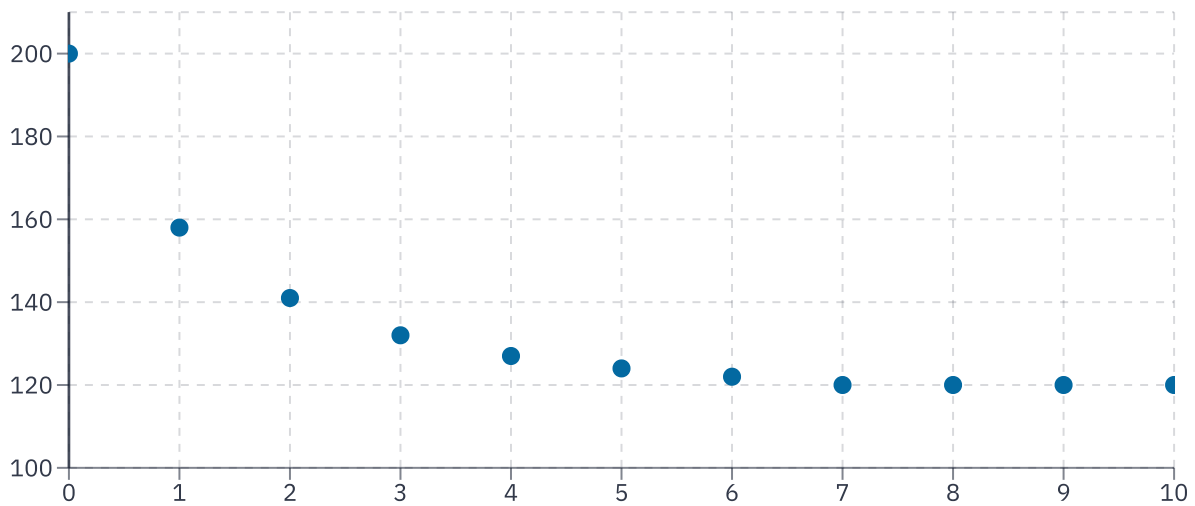
DOK 2 • Skills & concepts**Why DOK 2:** Students compare the model's built-in assumption with the plotted data and explain why that assumption limits accuracy, interpreting a graph.

A sports scientist models an athlete's heart rate recovery after a sprint using the function $h(t) = 80 + 120 \cdot \left(\frac{1}{2}\right)^{t/2}$, where t is time in minutes and $h(t)$ is heart rate in beats per minute. The graph shows actual measured data points. Which statement identifies a key assumption the scientist made in choosing this exponential decay model, and correctly explains why this assumption may limit the model's real-world accuracy?

Athlete's Recovery: Heart Rate Reduction After Sprint

Heart Rate (beats per minute) ↑

Time (minutes) →



- ☒ The model assumes heart rate decreases by a constant percentage each minute. This limits accuracy because the graph shows heart rate eventually levels off at about 120 bpm rather than continuing to decrease toward 80 bpm indefinitely. ✓
- ☐ The model assumes the exponent uses the rational number $\frac{1}{2}$ as the base. This limits accuracy because exponential models should always use natural base e instead.
- ☐ The model assumes that time is measured in minutes rather than seconds. This limits accuracy because the recovery process actually occurs much faster than the graph suggests.
- ☐ The model assumes the athlete's initial heart rate is exactly 200 bpm. This limits accuracy because different athletes may have different maximum heart rates depending on fitness level.

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DOK 3 · Strategic thinking

Why DOK 3: Students must analyze how three stated assumptions work together to shape the model and reason about when one would break down.

A sports analyst models the relationship between a basketball player's three-point shooting percentage and their average minutes played per game using the exponential function $P(m) = 85 - 45e^{-0.08m}$, where P is shooting percentage and m is minutes played. The analyst assumes that (1) increased playing time allows players to reach their "true" shooting ability, (2) there is a maximum biological/skill ceiling around 85%, and (3) the rate of improvement in shooting percentage decreases as minutes increase. Which statement best demonstrates understanding of the logical foundations and implications of these modeling assumptions?

- ☐ The assumptions are reasonable because exponential functions always model sports data accurately, and the 85% ceiling represents the average NBA three-point percentage.
- ☒ Assumptions (1) and (2) work together to justify the model's structure, but assumption (3) requires that improvement follows a decaying pattern—this breaks down if a player's shooting percentage actually declines after extended minutes due to fatigue or psychological factors not captured by the model. ✓
- ☐ The model is valid as long as the player's actual shooting percentage never exceeds 85%, which assumption (2) guarantees will never happen.
- ☐ Assumption (1) means the model only works for players with more than 20 minutes of playing time, since that is when shooting ability stabilizes.

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Test Bank question

4D Interpret results in the context of a situation

Assessed at: DOK 1 **DOK 2** DOK 3 DOK 4**DOK 2 • Skills & concepts**

Why DOK 2: Students determine the long-run behavior of a rational model and then judge whether that behavior is reasonable in the real context, a two-step interpretation.

A basketball coach models the relationship between a player's free-throw shooting percentage and the number of practice hours per week using the rational function $f(x) = \frac{95x}{x+3}$, where x is the number of practice hours and $f(x)$ is the shooting percentage. The coach uses this model to predict performance for players practicing between 0 and 15 hours per week.

Part A: According to the model, what does the behavior of $f(x)$ as x approaches infinity tell us about the player's shooting percentage with increasingly more practice hours?

Choose one answer.

- ☒ The shooting percentage approaches 95%, suggesting that no matter how much a player practices, their shooting percentage will asymptotically approach but never exceed 95%. ✓
- ☐ The shooting percentage increases without bound, so unlimited practice will eventually guarantee 100% or better shooting accuracy.
- ☐ The shooting percentage oscillates between 0% and 95% depending on the number of practice hours.
- ☐ The shooting percentage decreases toward zero because the denominator grows faster than the numerator.

Part B: Which observation best supports why this model's asymptotic behavior is reasonable in the real-world context of basketball free-throw shooting?

Choose one answer.

- ☐ The model is based on averaging the shooting percentages of all players on the team, so it naturally levels off at 95%.
- ☒ There is a physical and physiological limit to human performance; even elite free-throw shooters cannot achieve 100% accuracy, and additional practice eventually yields diminishing returns in improvement. ✓

- ☐ Free-throw shooting percentage is determined by factors other than practice, such as player fatigue during games, making the model invalid.
- ☐ Basketball players can theoretically improve indefinitely with more practice, so the model should show unbounded growth.

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must verify a result, interpret it in context, critique a conclusion drawn from it, and explain the model's limits, which requires reasoning from several pieces of information.

A town's population is modeled by $P(t) = 18,000(0.97)^t$, where t is years since 2020. A planner solves $P(t) = 9,000$, gets $t \approx 22.8$, and writes: 'The population halves every 22.8 years. So after another 22.8 years, about 45.6 years after 2020, the town will have no people left.'

- (a) Check whether $t \approx 22.8$ is correct and explain what it means.
- (b) Evaluate the planner's conclusion. What does the model actually predict for about 45.6 years after 2020?
- (c) Describe one reason the model's prediction far into the future may not be reliable.

Model response: (a) $0.97^t = 0.5$ gives $t = \frac{\log 0.5}{\log 0.97} \approx 22.8$. It means the population is predicted to fall to half of its 2020 value, 9,000 people, about 22.8 years after 2020 (in about 2043).

(b) The conclusion is incorrect. Halving again does not reach zero; it gives half of 9,000. $P(45.6) \approx 18,000(0.25) = 4,500$ people. An exponential decay model never reaches 0; it only gets closer to 0.

(c) For example, the 3% yearly decrease is unlikely to stay constant for 45 years because of births, people moving in, or new jobs, so long-range predictions are extrapolations beyond the data.

Rubric: 1 point: Confirms 22.8 and interprets it as a halving time, explains that the model predicts about 4,500 (not 0) people and that exponential decay never reaches 0, and gives a reasonable limitation.

0 points: Anything less, including a response that is only partly correct.

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4E Analyze adequacy and make improvements to existing models

Assessed at: DOK 1 DOK 2 DOK 3 DOK 4 DOK 4 is assessed only in the performance task.

DOK 2 • Skills & concepts

Why DOK 2: Students revise a model by fitting a square root function to two given conditions, setting up and solving a small system to improve the model.

A coach models the relationship between a basketball player's free throw percentage and the number of practice sessions using the linear model $P = 2.5s + 55$, where P is the free throw percentage and s is the number of practice sessions.

After collecting data from 10 players, the coach observes that:

- For players with fewer than 5 practice sessions, the model predicts percentages that are too high
- For players with more than 15 practice sessions, the model predicts percentages that are too high and exceeds 100%
- The actual data shows diminishing returns: improvements slow down as players practice more

The coach wants to modify the model to better capture the diminishing returns effect. Instead of using a linear model, the coach decides to use a square root model of the form $P = a\sqrt{s} + b$.

The coach determines that when $s = 4$, the model should predict $P = 65\%$, and when $s = 9$, the model should predict $P = 75\%$.

Find the value of a in the improved square root model. Round to the nearest tenth.

Correct answer: **10**

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Test Bank question

DOK 3 · Strategic thinking

Why DOK 3: Students must analyze where a cubic model gives unrealistic results, explain why, and propose and justify a specific improvement, which requires strategic thinking.

A sports economist models a college basketball arena's game-day ticket revenue $R(x)$ (in thousands of dollars) as a function of ticket price x (in dollars) using the polynomial $R(x) = -2x^3 + 20x^2 - 18x$. The economist claims this model reasonably describes revenue for every ticket price $x \geq 0$. (a) Rewrite $R(x)$ in factored form by first factoring out the greatest common factor and then factoring the remaining quadratic. (b) Use the factored form to identify all ticket prices where the model predicts zero revenue, and explain what happens to the sign of $R(x)$ for prices between the two positive zeros versus prices between 0 and the smaller positive zero. (c) Explain why the model's behavior for very low ticket prices is unrealistic, and propose a specific improvement (such as restricting the domain) that fixes this flaw while preserving the model's usefulness for setting prices.

Model response: Factoring: $R(x) = -2x(x^2 - 10x + 9) = -2x(x - 1)(x - 9)$. The zeros are $x = 0, 1, 9$. Testing a value between 0 and 1 (e.g., $x = 0.5$) gives $R(0.5) = -2(0.5)(-0.5)(-8.5) = -4.25$, so revenue is negative on $(0, 1)$. Testing a value between 1 and 9 (e.g., $x = 5$) gives $R(5) = -2(5)(4)(-4) = 160$, so revenue is positive on $(1, 9)$. This is unrealistic: at very low ticket prices (near \$0 to \$1), real-world revenue should be small and positive (a few dollars per ticket times many fans), not negative — revenue cannot actually be negative. This flaw occurs because the cubic model was likely fit to data only in the profitable price range and extrapolated incorrectly to low prices. A targeted improvement is to restrict the model's domain to $1 \leq x \leq 9$, the interval where $R(x) \geq 0$ matches realistic behavior, and to use a separate simple model (e.g., a linear model through the origin) for $0 \leq x \leq 1$ if predictions in that range are needed. This preserves the cubic's good fit and realistic maximum-revenue prediction in the useful range while removing the nonsensical negative-revenue output at low prices.

Rubric: 1 point: Correctly factors $R(x)$ as $-2x(x-1)(x-9)$, identifies zeros at 0, 1, 9, correctly analyzes sign behavior on both intervals, clearly explains why negative revenue at low prices is unrealistic, and proposes a specific, justified domain restriction or alternative fix.

0 points: Anything less, including a response that is only partly correct.

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Test Bank question

DOK 4 · Extended thinking

Why DOK 4: Students carry out an extended analysis across several conditions: they compute residuals, detect a pattern, build and test a new model, and compare long-range predictions.

A town's population is recorded every 5 years, where t is years since 2000.

t : 0, 5, 10, 15, 20

Population: 12,000; 13,600; 14,880; 15,904; 16,723

A planner uses the model $P(t) = 12,000(1.03)^t$.

- (a) Compute the model's predictions for each year in the table and the residuals (actual minus predicted). Describe the pattern in the residuals and what it says about the model.
- (b) Find the change in population over each 5-year interval. What pattern do you see, and what does it suggest about the long-run population?
- (c) Propose an improved model of the form $P(t) = L - C(b)^{t/5}$. Use the data to find L , C , and b , and test your model on the remaining data.
- (d) Compare the two models' predictions for $t = 30$ and explain which is more reasonable to use for planning.

Model response: (a) Predictions: 12,000; 13,911; 16,127; 18,696; 21,673. Residuals: 0; -311; -1,247; -2,792; -4,950. The residuals are all negative and growing, so the exponential model increasingly overestimates; growth is slowing, not compounding.

(b) Changes: 1,600; 1,280; 1,024; 819. Each change is about 0.8 times the previous one, so the increases shrink by a constant factor and the population is leveling off toward a limit.

(c) Summing the remaining changes as a geometric series, the population approaches $12,000 + \frac{1,600}{1-0.8} = 20,000$, so $L = 20,000$. Then $C = 20,000 - 12,000 = 8,000$ and $b = 0.8$: $P(t) = 20,000 - 8,000(0.8)^{t/5}$. Checks: $t = 10$: 14,880; $t = 15$: 15,904; $t = 20$: 16,723, matching the data.

(d) The improved model predicts about 17,903 at $t = 30$; the original predicts about 29,127. The improved model fits all the data and reflects slowing growth, so it is more reasonable for planning, though the planner should keep updating it as new data arrive.

Rubric: 1 point: All parts addressed with one error or one weak justification.

0 points: Anything less, including a response that is only partly correct.

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4F Identify important quantities in a practical situation and map their relationships (e.g., using diagrams, two-way tables, graphs, flow charts, or formulas)

Assessed at: **DOK 1** **DOK 2** **DOK 3** DOK 4**DOK 1 • Recall**

Why DOK 1: Students identify the independent quantity in a table, recalling what an input variable is in a familiar situation.

A high school basketball team tracks the relationship between the number of three-point shots attempted and the number made during their games. The coach creates a table to analyze this data:

Game	Three-Pointers Attempted	Three-Pointers Made
1	12	5
2	18	7
3	15	6
4	24	9

Which variable should be identified as the independent variable when mapping the relationship between these quantities?

- ☐ The game number, because it changes throughout the season
- ☒ Three-pointers attempted, because this is the quantity the team can directly control ✓
- ☐ Both variables equally, because they both appear in the table
- ☐ Three-pointers made, because this is what the team wants to maximize

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Test Bank question

Why DOK 2: Students must define variables, write the revenue relationship and two constraints, and organize them in a table or diagram, mapping several connected quantities.

A high school basketball team is planning a fundraiser where they sell two types of items: team t-shirts for \$12 each and hoodies for \$28 each. The team wants to raise at least \$840 and estimates they can sell at most 50 items total. Create a diagram or table that maps the relationship between the number of t-shirts sold, the number of hoodies sold, and the total revenue. Clearly label your variables and identify which quantities are independent and which are dependent. Explain how your representation helps you understand the constraints of this situation.

Model response: Let t = number of t-shirts sold (independent variable) and h = number of hoodies sold (independent variable). Total revenue R (dependent variable) = $12t + 28h$. Constraints: $t + h \leq 50$ and $12t + 28h \geq 840$. A table or diagram should show: (1) the two independent variables t and h as inputs, (2) the dependent variable R as output with the formula $R = 12t + 28h$ clearly labeled, and (3) the two constraints listed separately. For example, a sample table might show: if $t = 30$ and $h = 20$, then total items = 50 and $R = 360 + 560 = 920$ dollars (meets both constraints). The representation clarifies that revenue depends on both sales quantities and helps visualize which combinations of t and h satisfy both the item limit and revenue goal.

Rubric: 1 point: Student clearly identifies both independent variables (t and h) and dependent variable (R), writes the revenue formula correctly, lists both constraints, and either creates a table/diagram with labeled quantities or provides a written explanation of how the representation supports understanding the problem.

0 points: Anything less, including a response that is only partly correct.

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DOK 3 · Strategic thinking

Why DOK 3: Students must analyze how six quantities influence each other and identify feedback loops and constraints, reasoning about a whole system of relationships.

A high school soccer program is modeling attendance and revenue for the upcoming season. The athletic director identifies the following: ticket price per game (p dollars), number of games played (g), average attendance per game (a), total season revenue (R dollars), team winning percentage (w), and marketing budget (m dollars). The director notices that attendance depends on both winning percentage and marketing spend, winning percentage depends on player training hours and opponent strength, and revenue depends on both ticket price and attendance. Which of the following correctly identify critical feedback loops or constraints in this system that would significantly impact long-term sustainability? Select all that apply.

- ☐ Raising ticket price (p) will always increase total revenue (R) regardless of how attendance (a) responds to the price increase.
- ☐ A constraint exists where if winning percentage becomes too low, attendance drops significantly, reducing revenue available for marketing; this limits the program's ability to recover competitiveness without external funding. ✓
- ☐ Marketing effectiveness (the relationship between m and a) likely diminishes as winning percentage (w) decreases, meaning the program cannot simply "buy" attendance when the team performs poorly—this represents a critical interaction constraint. ✓
- ☐ The number of games played (g) is an independent variable that has no relationship to any other quantity in the system.
- ☐ Attendance per game (a) is solely determined by ticket price (p), making it independent of winning percentage and marketing.
- ☐ Increased marketing budget leads to higher attendance, which increases revenue, allowing for more player training resources, which improves winning percentage, which further increases attendance—creating a positive feedback loop. ✓

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4G Identify, analyze, and synthesize relevant external resources to pose or solve problems

Assessed at: DOK-1 DOK-2 **DOK 3** DOK 4 Assessed only in the performance task, at DOK 3 and 4.

DOK 3 • Strategic thinking

Why DOK 3: Students judge two external sources by sample size, precision, and units, and decide how they could be combined, evaluating resources with evidence.

A student is building a linear model that predicts a sprinter's 100-meter race time (in seconds) from weekly training distance (in miles). The student finds two external data sources: Source A is a report from the national track federation, based on 500 athletes, with times measured to the nearest 0.01 second and distances measured to the nearest 0.1 mile. Source B is a fan blog post based on 12 athletes, with times reported only as "fast," "medium," or "slow" and distances rounded to the nearest 10 miles. Decide whether each statement about using these sources is True or False.

	True	False
Source A is more appropriate for the model because its larger sample size and precise, consistent units allow for reliable quantitative analysis.	☒	☐
Source B's categorical labels ("fast," "medium," "slow") can be directly averaged with Source A's numerical times without redefining units, since both describe speed.	☐	☒
Before combining data from both sources, the student should convert all measurements to the same units and check that both sources define "training distance" and "race time" the same way.	☒	☐
Because Source B has a much smaller sample size and less precise measurements, conclusions drawn from it should be treated as less reliable than those from Source A.	☒	☐
Reporting the final model's predicted race time to the nearest 0.0001 second is appropriate, since more decimal places always make a prediction more scientifically valid.	☐	☒

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Test Bank question

DOK 4 · Extended thinking

Why DOK 4: Students must locate and evaluate several external sources, weigh their credibility and bias, and synthesize them into a plan for improving a model, an extended task.

A high school athletic director wants to model the relationship between weekly practice hours and team performance scores for the volleyball team over a season. She collects internal data showing practice hours (x) and match scores (y) for 8 weeks. However, she wants to improve her model's reliability by incorporating external data sources. Identify at least two external data sources you would recommend she consult, explain why each source is relevant and credible for this modeling purpose, and discuss any limitations or potential biases in these sources that could affect the accuracy of her linear model. Finally, explain how she should adjust her measurement precision (number of decimal places) when recording practice hours and scores based on the reliability of her combined data.

Model response: A strong response identifies sources such as: (1) published NCAA or high school athletic association benchmarking reports on practice-performance correlations, credible because they represent large populations and are peer-reviewed; (2) sports science research from university kinesiology departments, credible because they use controlled methodology but may not reflect this specific team's context; and (3) similar teams' public performance records, relevant for local comparison but limited by different coaching styles and player abilities. The response discusses limitations such as: external data may not account for variables like player injuries, roster changes, or team chemistry specific to this school; measurement bias in scoring systems may differ between matches; and practice hours alone may not capture practice quality. For measurement precision, the director should use whole numbers or one decimal place for practice hours (limited by scheduling precision) and integer scores (based on standard scoring systems), avoiding false precision that external data cannot support. The response should note that combining sources helps validate patterns but requires careful statistical interpretation to avoid overfitting.

Rubric: 1 point: Student identifies and locates at least two relevant external sources, discusses data quality, and attempts to integrate sources into modeling with some discussion of limitations.
0 points: Anything less, including a response that is only partly correct.

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Sources

- Smarter Balanced Assessment Consortium, 2015–16 Summative Technical Report: claim statements, and the Appendix 2.A test blueprints (pp. 43–48), which list the DOK levels assessed for every claim and target. <https://www.cde.ca.gov/ta/tg/ca/documents/sb16sbtechrpt.pdf>
- Target wording and standards: Smarter Balanced Mathematics Content Specifications and the CCSS for Mathematics, as stored in the AchieveMetrics Test Bank.

- DOK level definitions: Smarter Balanced Content Specifications (Webb Depth of Knowledge), summarised on the "How to use" page.
- Example questions: the AchieveMetrics Test Bank, reviewed for this guide.

AchieveMetrics Test Bank · DOK Progression Guide · Math 3 · October 2026 edition.

