Exponential Functions

Name: ______________	Date: ______________	Score: ______ / 35

Quick Review

An **exponential function** has the form $f(x) = a \cdot b^x$, where $a \neq 0$ is the *initial value*, $b > 0$ is the *base* (also called the growth or decay factor), and $b \neq 1$. The variable lives *in the exponent*, which is what makes the family special: small steps in x produce *multiplicative* jumps in y.

Growth vs decay. With $a > 0$: if $b > 1$, the function *grows* (each step multiplies by b); if $0 < b < 1$, it *decays*. $f(x) = 3 \cdot 2^x$ grows — doubling each unit. $g(x) = 4 \cdot (0.5)^x$ decays — halving each unit.

Y-intercept is always a. Because $b^0 = 1$, $f(0) = a \cdot 1 = a$. So the constant in front *is* where the curve crosses the y-axis.

Horizontal asymptote at $y = 0$. The graph approaches the x-axis but never touches it. (Shift the function up by k and the asymptote moves to $y = k$ — that's how you read a transformed exponential off a graph.)

Finding a and b from two points. If $f(0) = a$ is given, you have a for free. Otherwise, use $f(0)$. To get b, plug a second point in and solve. Quick check: $f(0) = 6$ and $f(2) = 24$ gives $a = 6$, then $6b^2 = 24$ so $b^2 = 4$ and $b = 2$ (positive branch). **Common traps.** $f(x) = ax^b$ is a *power* function, not exponential — the variable belongs in the exponent. The range of $f(x) = a \cdot b^x$ (no shift, $a > 0$) is $y > 0$ — *strictly* positive — because $b^x > 0$ for every real x.

PRACTICE

Evaluate, identify, or graph each exponential function.

1. $f(x) = 3 \cdot 2^x;\ f(4)$ ________
2. $f(x) = 5 \cdot 3^x;$ y-intercept ________
3. $g(x) = 4 \cdot (0.5)^x;$ growth or decay? ________
4. $f(x) = 2^x;$ domain and range ________
5. $f(x) = a \cdot b^x,\ f(0) = 6,\ f(2) = 24,\ b > 0;$ find b ________
6. Is $3 \cdot 2^x$ an exponential function? ________
7. Is $3x^2$ an exponential function? ________
8. $f(x) = 7 \cdot 2^x;\ f(0) + f(3)$ ________
9. Horizontal asymptote of $y = 3 \cdot 2^x$ ________
10. Horizontal asymptote of $y = 3 \cdot 2^x + 5$ ________
11. $f(x) = a \cdot b^x,\ f(0) = 7,\ f(3) = 56;$ formula ________

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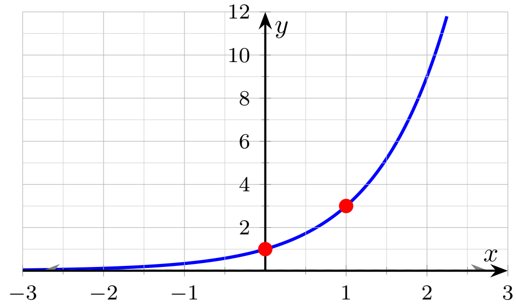
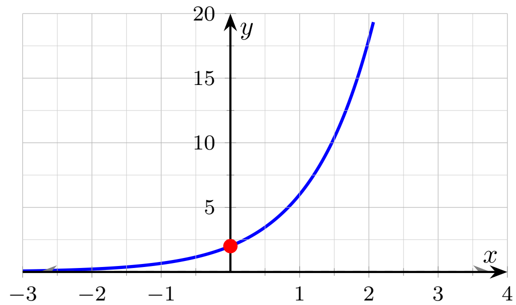
12. The graph below shows $y = 3^x$. Name two integer points it passes through. ________

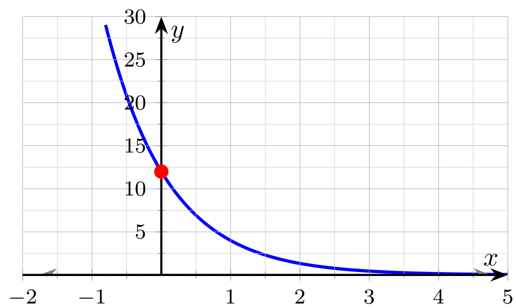


13. $f(x) = 10 \cdot (0.8)^x;\ f(2)$ ________

14. The graph below shows $f(x) = 2 \cdot 3^x$. Identify the y-intercept. ________



15. The graph below shows $g(x) = 12 \cdot (1/3)^x$. Is this growth or decay, and what is $g(0)$? ________



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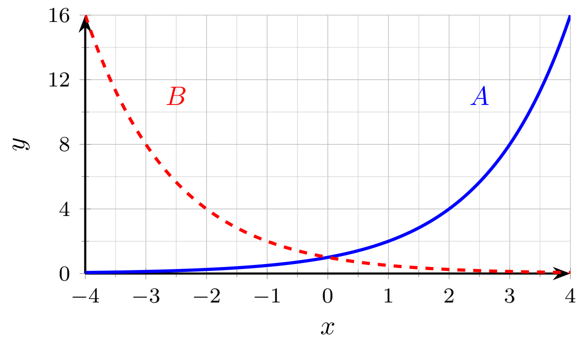
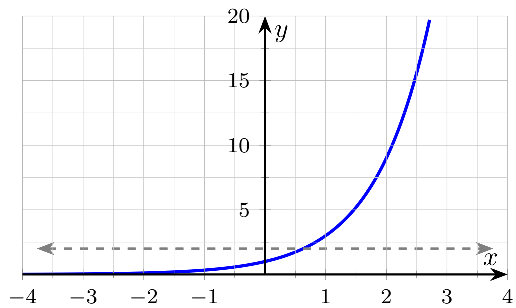
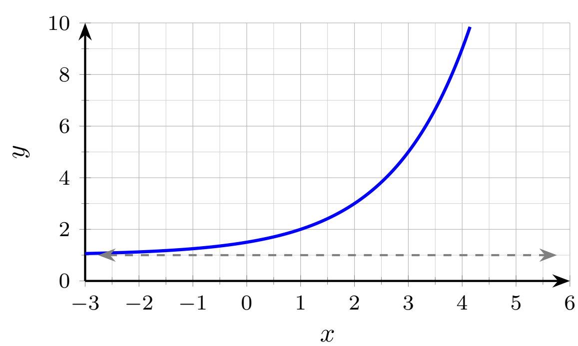
16. Which curve below is $y = 2^x$? ________



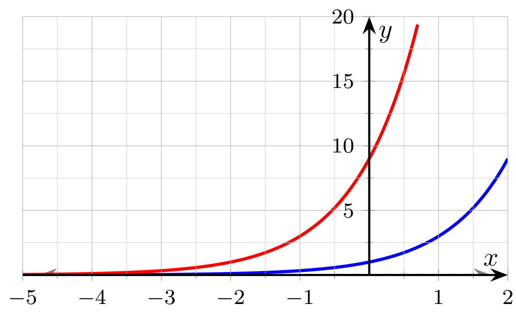
17. The graph below shows $f(x) = 3^x + 2$. What is the horizontal asymptote? ________



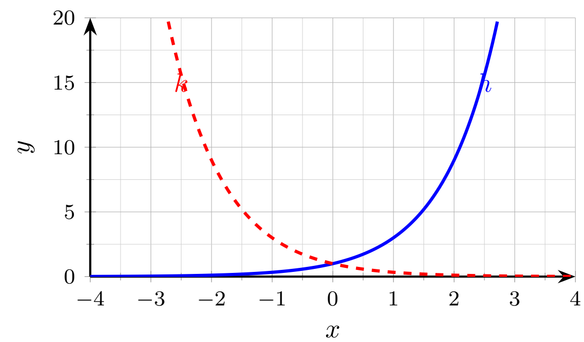
18. The graph shown is $f(x) = 2^{x-1} + 1$. What is the asymptote? ________



19. The graph below shows $h(x) = 3^{x+2}$. How does it relate to $f(x) = 3^x$? ________

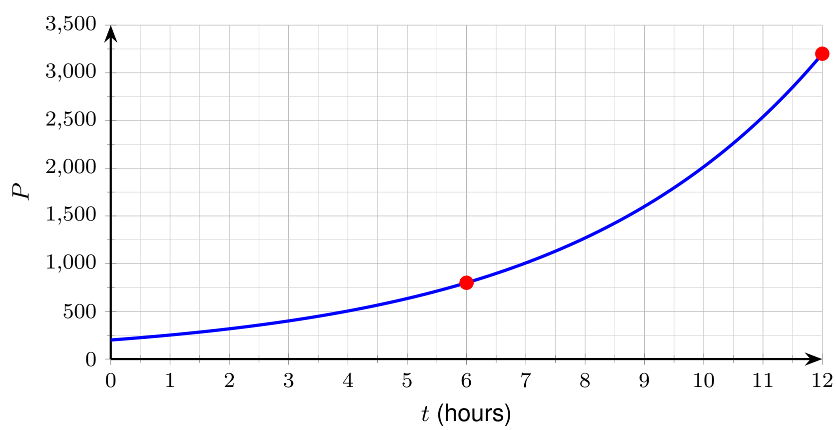


20. The graph below shows $k(x) = 3^{-x}$. How does it relate to $h(x) = 3^x$? ________

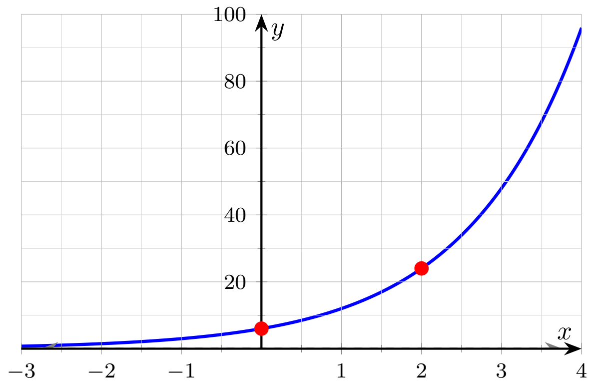


♦ Word Problems

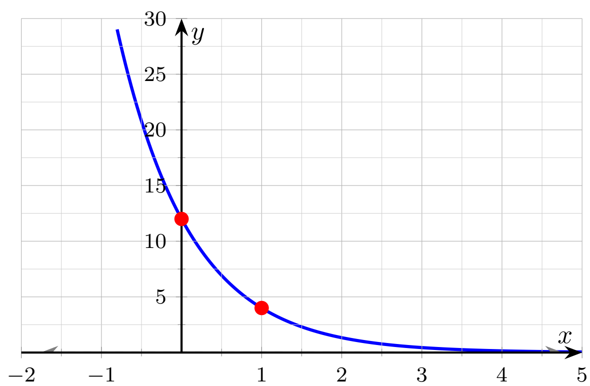
21. A bacterial population doubles every 3 hours. The colony starts at 200 bacteria. Use the model $P(t) = 200 \cdot 2^{t/3}$ and the graph below to find the population after 6 hours and after 12 hours. ________



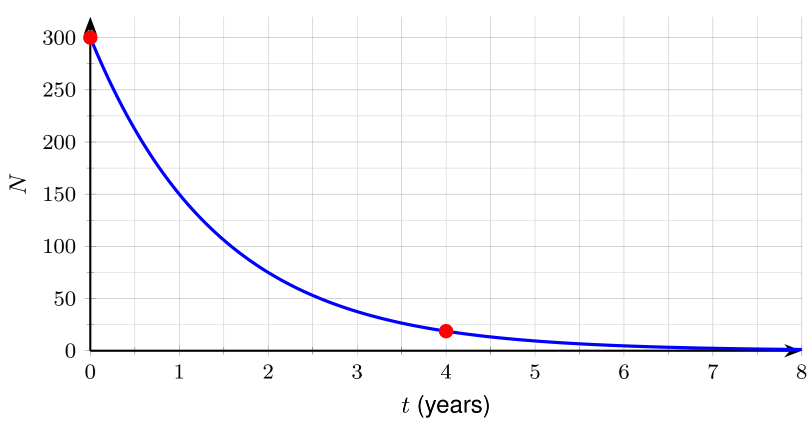
22. An exponential function has the form $f(x) = a \cdot b^x$. You're given $f(0) = 6$ and $f(2) = 24$, with $b > 0$. Find a, find b, and write the formula. Sketch the resulting curve on the plane below. ____



23. Match the graph below to one of: $A.\ y = 6(3)^x$, $B.\ y = 12(1/3)^x$, $C.\ y = 12(3)^x$, $D.\ y = 6(1/3)^x$. Justify by reading the y-intercept and shape. ____



24. A scientist counts 300 tagged frogs in a pond. The population shrinks by half every year due to habitat loss. Write an exponential model for the number of tagged frogs after t years, and predict the count after 4 years. The graph below shows the decay curve. ________



Additional Practice

25. Evaluate $3 \cdot 2^4$. ________

26. Find a in $y = a \cdot 3^x$ if $y(0) = 7$. ________

27. Growth or decay: $y = 12(0.8)^x$. ________

28. Growth or decay: $y = 5(1.12)^t$. ________

29. Find y when $x = 3$ for $y = 2^x + 1$. ________

30. Solve $2^x = 32$. ________

31. Solve $5^x = 125$. ________

32. Initial value of $P = 400(1.05)^t$. ________

33. Rate in $P = 900(1.08)^t$. ________

34. Rate in $A = 1200(0.92)^t$. ________

35. Double 60 three times. ________

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Answer Keys

1. 48
2. 5
3. decay
4. $\mathbb{R};\ y > 0$
5. 2
6. yes
7. no (it's a power/quadratic)
8. 63
9. $y = 0$
10. $y = 5$
11. $f(x) = 7 \cdot 2^x$
12. $(0, 1)$ and $(1, 3)$
13. 6.4
14. 2
15. decay; $g(0) = 12$
16. A
17. $y = 2$
18. $y = 1$
19. shifted left 2 units
20. reflection across the y-axis
21. $P(6) = 800,\ P(12) = 3200$
22. $a = 6,\ b = 2,\ f(x) = 6 \cdot 2^x$
23. $B.\ y = 12(1/3)^x$
24. $N(t) = 300 \cdot (0.5)^t;\ N(4) \approx 19$

Additional Practice Answers

25. 48
26. $a = 7$
27. decay
28. growth
29. 9
30. $x = 5$
31. $x = 3$
32. 400
33. 8%
34. 8% decay
35. 480

Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

1. Exponent first: $2^4 = 16$. Then multiply: $3 \cdot 16 = 48$. (A common slip is to multiply first, getting $6^4 = 1296$ — order of operations says the exponent binds tighter.)

2. Set $x = 0$: $f(0) = 5 \cdot 3^0 = 5 \cdot 1 = 5$. Any $b^0 = 1$, so the y-intercept of $a \cdot b^x$ is always a.

3. Look at the base: $b = 0.5$, and since $0 < b < 1$ the function decays. Each unit step multiplies by 0.5, so the output halves and the curve falls as x increases. (If b were greater than 1, it would grow instead.)

4. You can raise 2 to any real power, so the domain is all reals. For the range, note 2^x is positive for every x and approaches 0 but never reaches it, so the range is $y > 0$ — strictly positive, never zero or negative.

5. A careful way to see it: $f(0) = a = 6$. Then $6b^2 = 24$, so $b^2 = 4$. Positive branch: $b = 2$. (Don't forget the positivity constraint — b must be positive in the standard exponential form.) That gives a quick check on the answer.

6. Match it to the form $a \cdot b^x$: here $a = 3$ and $b = 2$, with $b > 0$ and $b \neq 1$. The variable sits in the exponent, which is exactly what makes a function exponential.

7. Here the variable x is the base and the exponent 2 is constant — the reverse of an exponential. That makes it a power (quadratic) function, not exponential.

8. Evaluate each piece separately. $f(0) = 7 \cdot 2^0 = 7 \cdot 1 = 7$, and $f(3) = 7 \cdot 2^3 = 7 \cdot 8 = 56$. Add them: $7 + 56 = 63$.

9. There is no vertical shift added to the function, so the asymptote stays at the parent location $y = 0$. As $x \to -\infty$, $2^x \to 0$, so the curve hugs the x-axis from above without ever touching it.

10. Start from the parent $3 \cdot 2^x$, whose asymptote is $y = 0$. The $+5$ shifts the entire graph up by 5, so the asymptote moves up with it to $y = 5$.

11. Use the easy point first: $f(0) = a \cdot b^0 = a = 7$, so $a = 7$. Then plug in the second point: $7b^3 = 56$ gives $b^3 = 8$, so $b = 2$. The formula is $f(x) = 7 \cdot 2^x$.

12. At $x = 0$, $y = 3^0 = 1$. At $x = 1$, $y = 3$. Every $a \cdot b^x$ with $a = 1$ passes through $(0, 1)$. The two red dots mark these anchor points.

13. Handle the exponent first: $0.8^2 = 0.64$. Then multiply by the initial value: $10 \cdot 0.64 = 6.4$. Since $0.8 < 1$, the output came out smaller than the starting 10, just as decay predicts.

14. Keep the rule visible: Set $x = 0$: $y = 2 \cdot 3^0 = 2$. The red dot marks $(0, 2)$ on the curve. That gives a quick check on the answer.

15. Base $\frac{1}{3} < 1$ means decay — the curve falls. At $x = 0$: $g(0) = 12$. The dot marks the intercept.

16. Start with the key idea: 2^x grows as x increases (rising right). Curve A does that. Curve B is $(1/2)^x$ — decay, falls right. That gives a quick check on the answer.

17. The $+2$ shifts the parent 3^x up by 2, taking the asymptote with it. (Be careful: the dashed line in the figure is at $y = 2$, not the x-axis.)

18. Vertical shift up by 1 moves the asymptote to $y = 1$. (The $x - 1$ shifts horizontally; it doesn't touch the horizontal asymptote.)

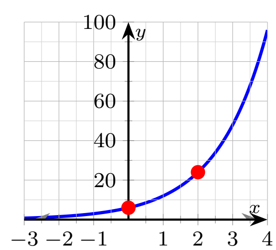
19. One steady path is: $3^{x+2} = f(x + 2)$. Replacing x with $x + 2$ shifts left by 2 (think: the input has to be smaller by 2 to get the same output, so the curve slides left). That gives a quick check on the answer.

20. Start with the key idea: $3^{-x} = h(-x)$. Replacing x with $-x$ flips the curve across the y-axis. The growth curve becomes a decay curve. That gives a quick check on the answer.

21. Plug in directly. $P(6) = 200 \cdot 2^{6/3} = 200 \cdot 2^2 = 800$. $P(12) = 200 \cdot 2^{12/3} = 200 \cdot 2^4 = 200 \cdot 16 = 3200$. Notice the doubling rhythm: $200 \to 400 \to 800$ over the first six hours (two doublings), then $\to 1600 \to 3200$ over the next six. The marked points on the curve confirm both values.

22. Start with the easier point: $f(0) = a \cdot b^0 = a$. So $a = 6$. Now use the second point: $f(2) = 6b^2 = 24$, so $b^2 = 4$ and (since $b > 0$) $b = 2$. The formula is $f(x) = 6 \cdot 2^x$. The two red dots mark the data points; the curve passes through both.

Answer graph



23. Two checkpoints make this quick. The y-intercept is a (because $b^0 = 1$), and the graph crosses at $(0, 12)$, so $a = 12$ — rules out A and D. The curve falls as x increases, so $0 < b < 1$ — rules out C. That leaves B: $y = 12(1/3)^x$. Sanity-check: at $x = 1$, $12 \cdot \frac{1}{3} = 4$, matching the second dot.

24. Halving each year means the multiplier is 0.5, so $N(t) = 300 \cdot (0.5)^t$. After 4 years: $N(4) = 300 \cdot (0.5)^4 = 300 \cdot 0.0625 = 18.75$, or about 19 frogs. (Halving four times: $300 \to 150 \to 75 \to 37.5 \to 18.75$. Same answer the long way.)

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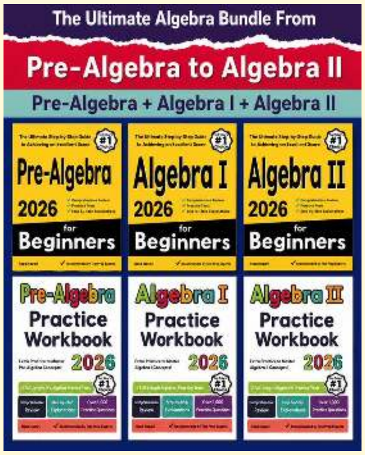

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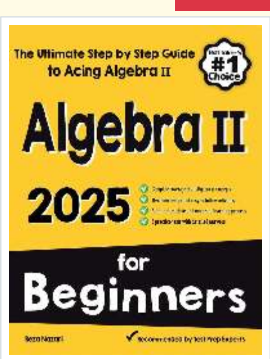

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