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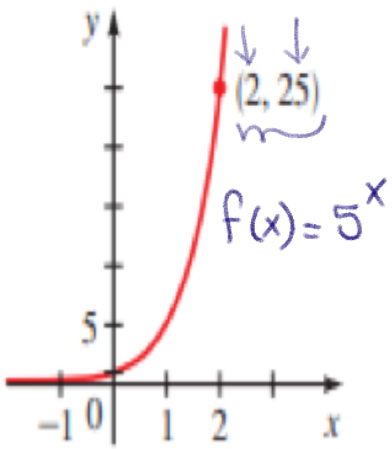
EXAMPLE 3 ■ Identifying Graphs of Exponential Functions

Find the exponential function $f(x) = a^x$ whose graph is given.

(a)



$f(x) = 5^x$

$(-2, \frac{1}{a^2})(-1, \frac{1}{a})(0,1)(1,a)(2,a^2)$

at $x = 2 \rightarrow f(x) = a^2$

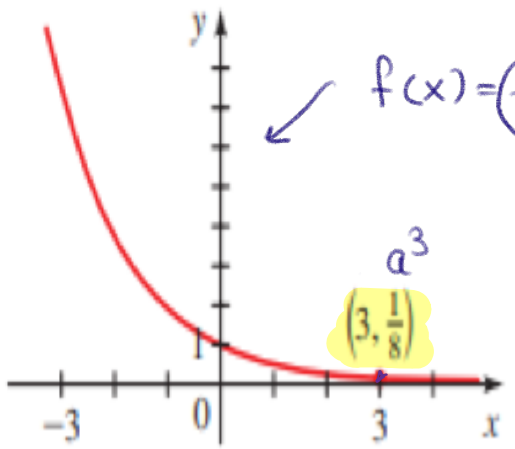
$a^2 = 25$

$a^2 = 5^2$

$a = 5$

$f(x) = a^x = 5^x$

(b)



$f(x) = (\frac{1}{2})^x$

a^3

$(3, \frac{1}{8})$

$(-2, \frac{1}{a^2})(-1, \frac{1}{a})(0,1)(1,a)(2,a^2)(3,a^3)$

at $x = 3 \rightarrow f(x) = a^3$

$a^3 = \frac{1^3}{8}$

$= \frac{1^3}{2^3} = (\frac{1}{2})^3$

$a^3 = (\frac{1}{2})^3$

$a = \frac{1}{2}$

$f(x) = a^x = (\frac{1}{2})^x$

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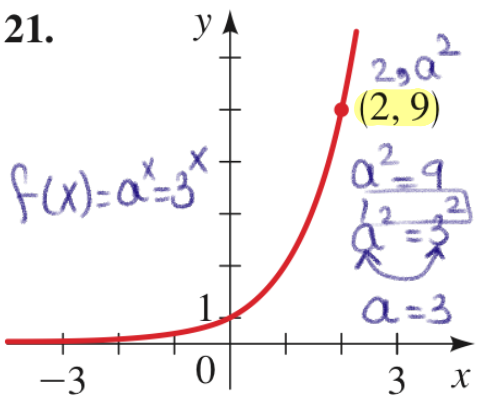
21–24 ■ Exponential Functions from a Graph Find the exponential function $f(x) = a^x$ whose graph is given.

21.



$f(x)=a^x=3^x$

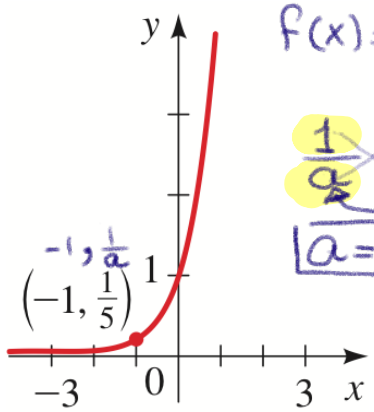
$2, a^2$

$a^2=9$

$a^2=3^2$

$a=3$

22.



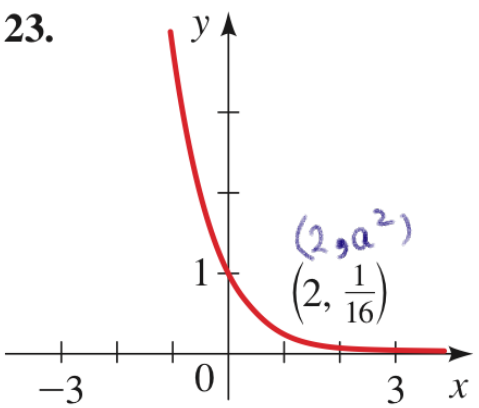
$f(x)=a^x=5^x$

$-1, \frac{1}{a}$

$\frac{1}{a}=\frac{1}{5}$

$a=5$

23.



$(2, a^2)$

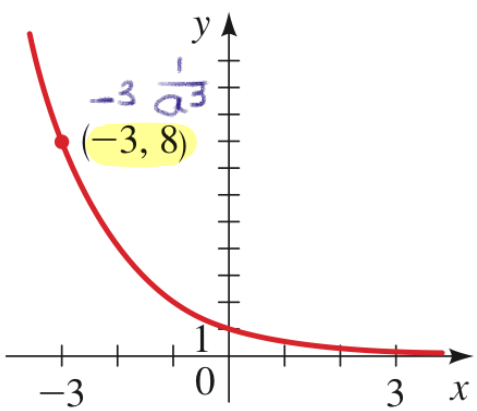
$a^2=\frac{1}{16}$

$a^2=\frac{1^2}{4^2}=\left(\frac{1}{4}\right)^2$

$a=\frac{1}{4}$

$f(x)=a^x=\left(\frac{1}{4}\right)^x$

24.



$-3, \frac{1}{a^3}$

$\frac{1}{a^3}=\frac{8}{1}$

$\frac{8a^3}{8}=\frac{1}{8}$

$a^3=\frac{1}{8}=\frac{1^3}{2^3}=\left(\frac{1}{2}\right)^3$

$a=\frac{1}{2} \rightarrow f(x)=\left(\frac{1}{2}\right)^x$

Translation انتقال

$f(x) = a^x$

Horizontal

- Left
- right

$F(x) = f(x \pm c)$ (بعد الحركة)

$F(x) = a^{x \pm c}$ ← حركة افقية

- $+$ → يسار Left
- $-$ → يمين right

$F(x) = a^{x+c}$ → Left

$F(x) = a^{x-c}$ → right

Vertical

- up ↑
- ↓ down

$F(x) = f(x) \pm c$ (بعد الحركة) (الرقم بره)

$F(x) = a^x \pm c$

- $+$ ↑ up
- $-$ ↓ down

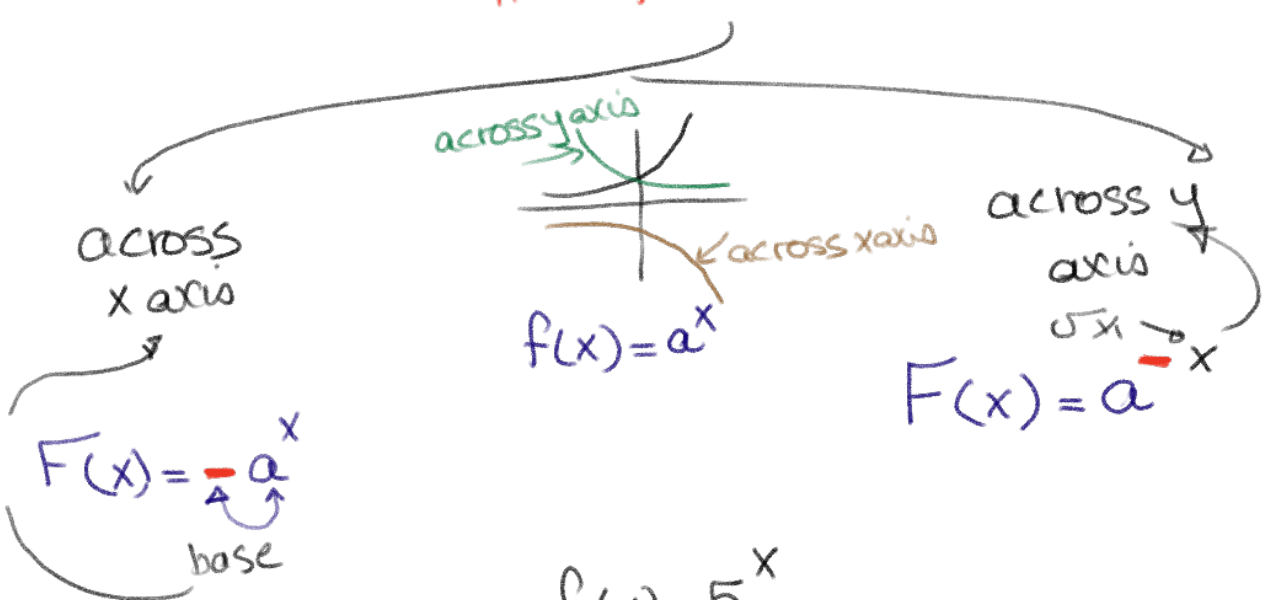
$F(x) = a^x + c$ → up

$F(x) = a^x - c$ → down

$f(x) = 5^x$ ⟶ 2units up, down, right, Left

1. up by 2units ⟶ $F(x) = 5^x + 2$
2. down by 2units ⟶ $F(x) = 5^x - 2$
3. Right by 2units ⟶ $F(x) = 5^{x-2}$
4. Left by 2units ⟶ $F(x) = 5^{x+2}$

Reflection انعكاس



$f(x) = 5^x$

$F(x) = -5^x$

$F(x) = 5^{-x}$

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Let $f(x) = b^x$, $b \neq 1$

1. **Vertical Translation**

If $F(x) = b^x + c = f(x) + c$, then graph of F is vertical translation of f c units upward.

If $F(x) = b^x - c = f(x) - c$, then graph of F is vertical translation of f c units downward.

2. **Horizontal Translation**

If $G(x) = b^{x+c} = f(x + c)$, then graph of G is horizontal translation of f c units to the left.

If $G(x) = b^{x-c} = f(x - c)$, then graph of G is horizontal translation of f c units to the right.

3. **Reflection**

If $H(x) = b^{-x} = f(-x)$, then graph of H is the graph of f reflected across the y-axis.

If $H(x) = -b^x = - f(x)$, then the graph of H is the graph of f reflected across the x-ax

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EXAMPLE 4 ■ **Transformations of Exponential Functions**

Use the graph of $f(x) = 2^x$ to sketch the graph of each function. State the domain, range, and asymptote.

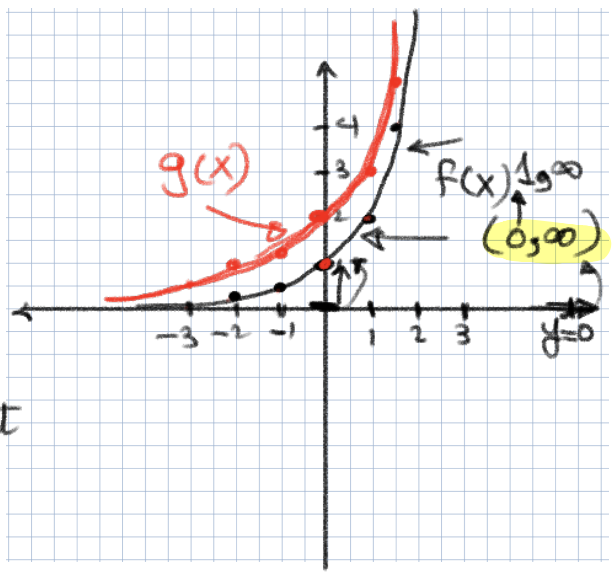
(a) $g(x) = 1 + 2^x$ → $2^x + 1$ →

[1] Graph of $f(x) = 2^x$

$a = 2$

$(-2, \frac{1}{a^2})(-1, \frac{1}{a})(0,1)(1,a)(2,a^2)$

$(-2, \frac{1}{4})(-1, \frac{1}{2})(0,1)(1,2)(2,4)$



The graph of 2^x shift up by 1 unit

Domain $R \rightarrow (-\infty, \infty)$

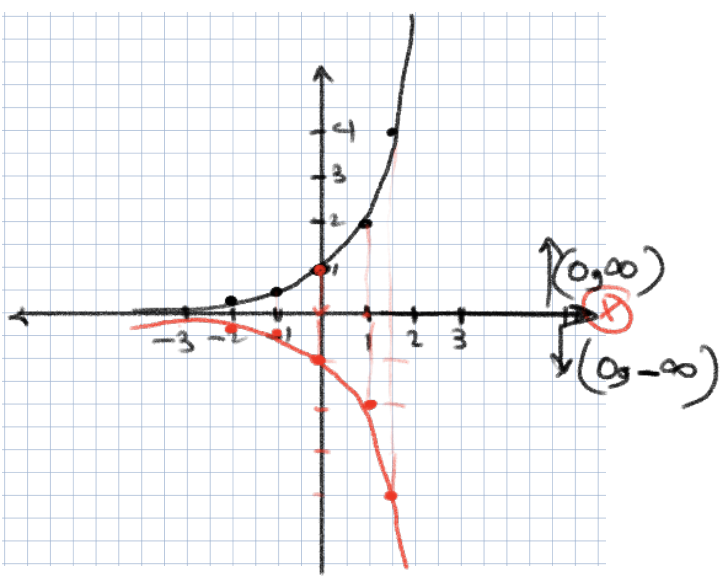
Range $\rightarrow (1, \infty)$

H. Asymptote $\rightarrow y = 1$

(b) $h(x) = -2^x$

Upside down

Graph of 2^x reflect across x axis



Domain $\rightarrow (-\infty, \infty)$

Range $\rightarrow (0, -\infty)$

H. Asymptote $y = 0$

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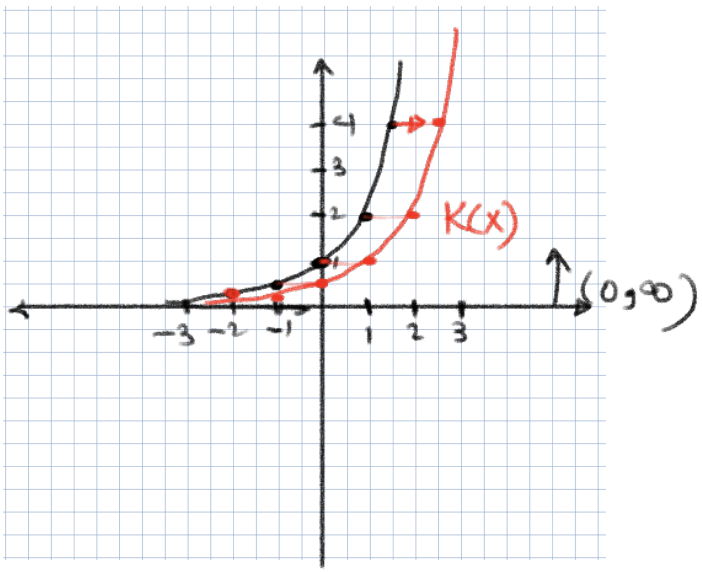
(c) $k(x) = 2^{x-1}$

The graph of 2^x shift to the right by 1 unit

Domain $(-\infty, \infty)$

Range $(0, \infty)$

H. Asymptote $y=0$



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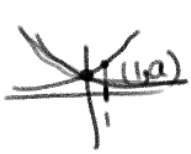
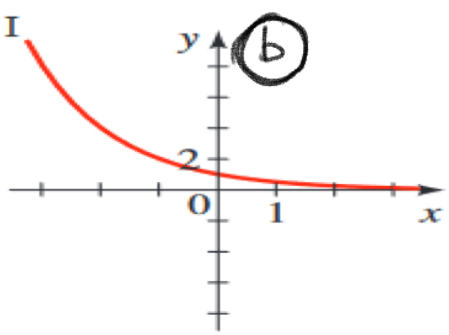
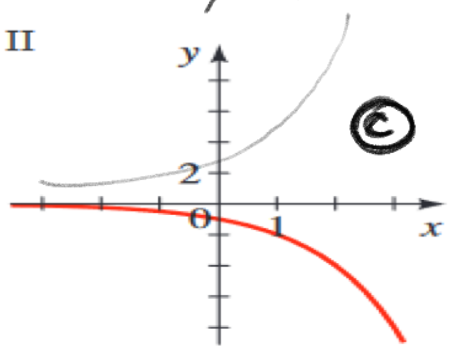


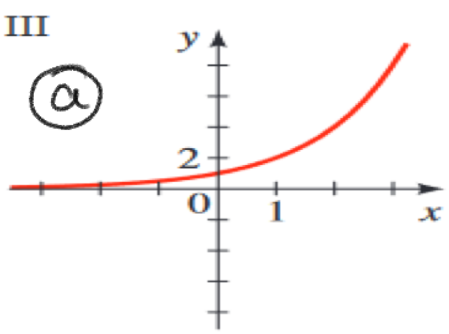
2. Match the exponential function with one of the graphs labeled I, II, III, or IV, shown below.

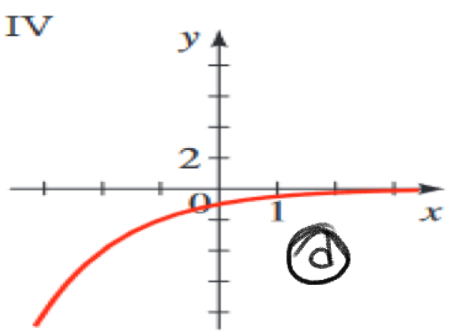
(a) $f(x) = 2^x$ **(b)** $f(x) = 2^{-x}$

(c) $f(x) = -2^x$ **(d)** $f(x) = -2^{-x}$









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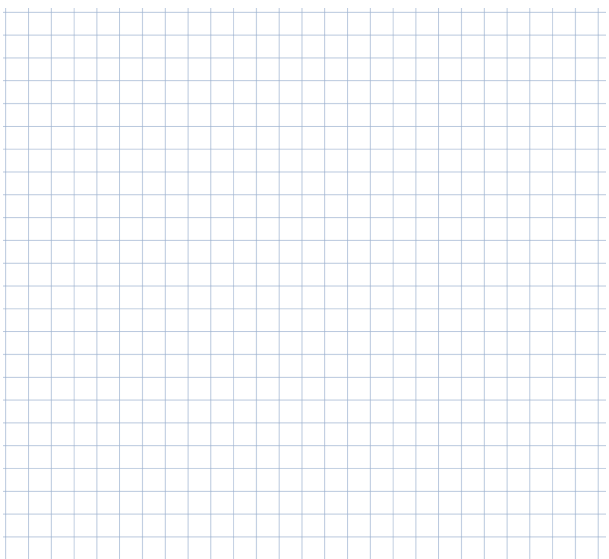
17–20 ■ Graphing Exponential Functions Graph both functions on one set of axes.

H.W

18. $f(x) = 3^{-x}$ and $g(x) = \left(\frac{1}{3}\right)^x$

انعكاس الجراف حول محور y



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$f(x)=3^x$

27–40 ■ Graphing Exponential Functions Graph the function, not by plotting points, but by starting from the graphs in Figure 2. State the domain, range, and asymptote.

29. $f(x) = -3^x$

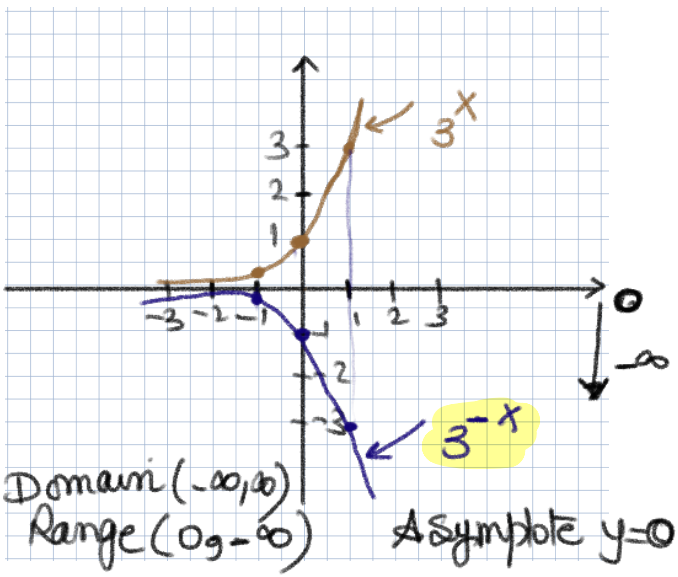
الاساس حق x

$a=3$

$(-1, \frac{1}{a})(0,1)(1,a)$

$(-1, \frac{1}{3})(0,1)(1,3)$

The graph reflect across x axis



31. $f(x) = 10^{x+3}$ اقفيه بيار

$10^x \rightarrow a=10$

$(-1, \frac{1}{a})(0,1)(1,a)$

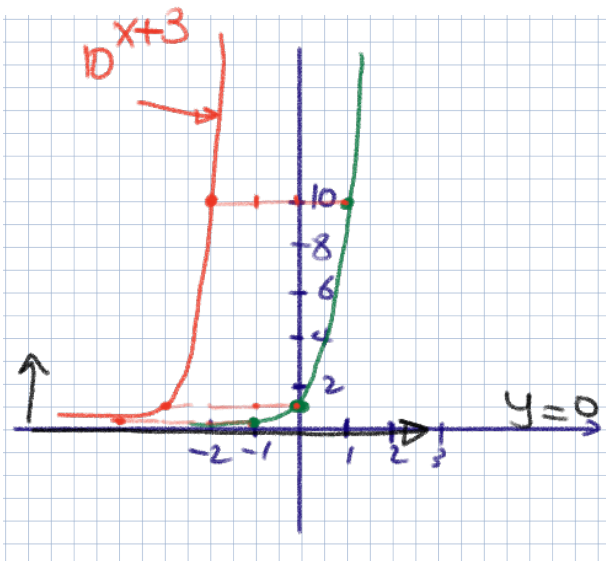
$(-1, \frac{1}{10})(0,1)(1,10)$

The graph is shifted to the Left by 3 units

Domain $(-\infty,\infty)$

Range $(0,\infty)$

H Asymptote $\rightarrow y=0$



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عرفة اهمية الى الجيم

32. $g(x) = 2^{x-3}$

$2^x \rightarrow a = 2$

$(-1, \frac{1}{a})(0,1)(1,a)$

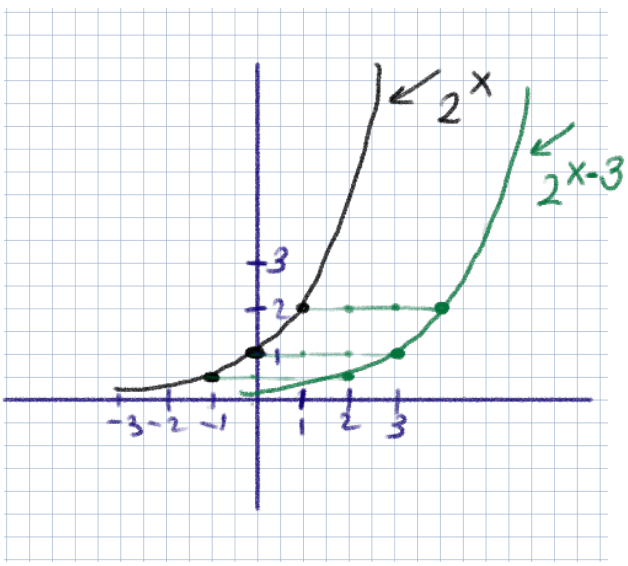
$(-1, \frac{1}{2})(0,1)(1,2)$

Domain $(-\infty, \infty)$

Range $(0, \infty)$

H. Asymptote $y = 0$

انعكاس حول محور x



35. $y = +2 - \left(\frac{1}{3}\right)^x$

عرفة اعلى

$\left(\frac{1}{3}\right)^x \rightarrow a = \frac{1}{3}$

$(-1, \frac{1}{a})(0,1)(1,a)$

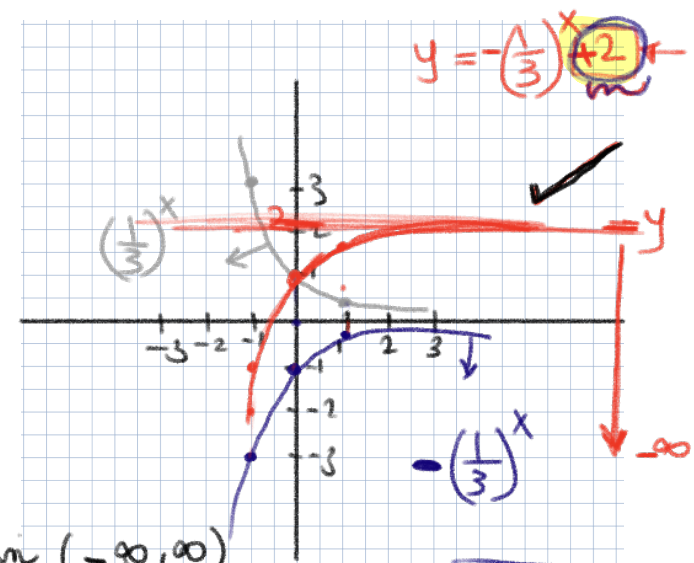
$(-1, 3)(0,1)(1, \frac{1}{3})$

$y = -\left(\frac{1}{3}\right)^x + 2$

① ↓ 2

The graph of $\left(\frac{1}{3}\right)^x$ reflect across x axis then Shifted up by 2 units → Domain $(-\infty, \infty)$

Range → $(2, -\infty)$ → H. Asymptote $y = 2$



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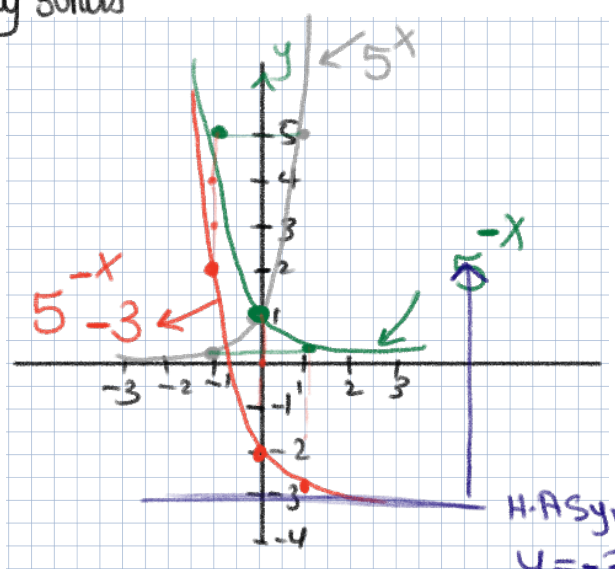
reflect across y axis

36. $y = 5^{-x} - 3$ → shift down by 3 units

$5^x \rightarrow a = 5$

$(-1, \frac{1}{a})\ (0,1)\ (1,a)$

$(-1, \frac{1}{5})\ (0,1)\ (1,5)$



the graph of $y = 5^x$

Reflect across y axis

then shifted down

by 3 units

Domain $(-\infty, \infty)$

Range $(-3, \infty)$

H. Asymplote $y = -3$