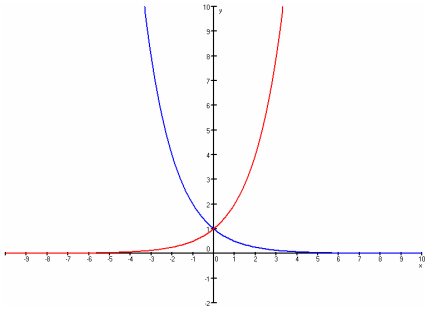
Hoofdstuk 5: Exponenten en logaritmen.

5.1 De standaardfunctie $f(x) = g^x$

Opgave 1:



a. De grafiek van g ontstaat door de grafiek van f te spiegelen in de x-as.

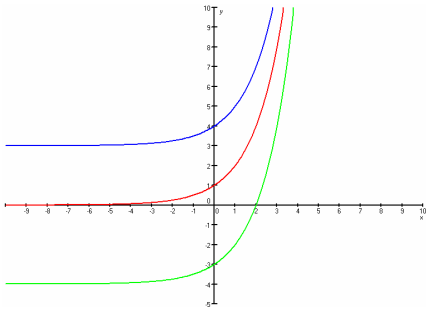
b. $y = 0$

c. $B_f = \langle 0, \rightarrow \rangle$

$B_g = \langle 0, \rightarrow \rangle$

Opgave 2:

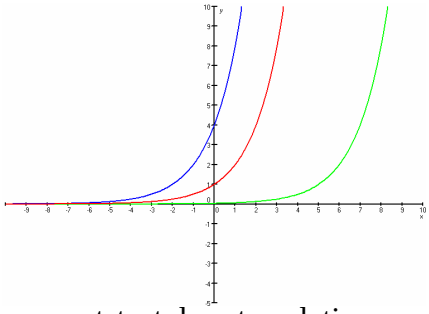
a.



y_2 ontstaat door translatie over $(0,3)$

y_3 ontstaat door translatie over $(0,-4)$

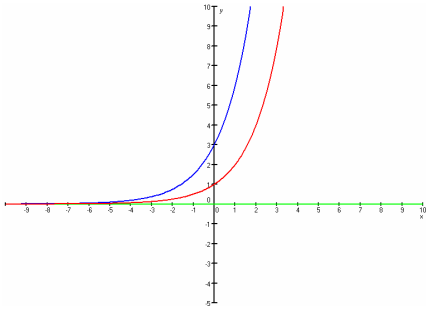
b.



y_4 ontstaat door translatie over $(-2,0)$

y_5 ontstaat door translatie over $(5,0)$

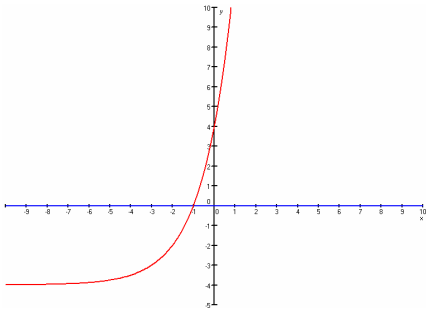
c.



y_6 ontstaat door vermenigvuldiging ten opzichte van de x-as met 3

Opgave 3:

a. translatie over $(-3,-4)$

b. 

$B_f = \langle -4, \rightarrow \rangle$

c. $y_1 = 2^{x+3} - 4$ en $y_2 = 2$
intersect geeft $x = -0{,}42$
dus $x \leq -0{,}42$

d. $f(3) = 60$
dus $-4 < x \leq 60$

Opgave 4:

a. translatie over $(1,5)$
H.A.: $y = 5$

b. translatie over $(-1,0)$ daarna vermenigvuldiging t.o.v. de x-as met 5
H.A.: $y = 0$

c. translatie over $(0,-7)$ daarna vermenigvuldiging t.o.v. de x-as met 4
H.A.: $y = -7$

d. translatie over $(0,3)$ daarna vermenigvuldiging t.o.v. de x-as met -2
H.A.: $y = 3$

Opgave 5:

a. $N = -6$

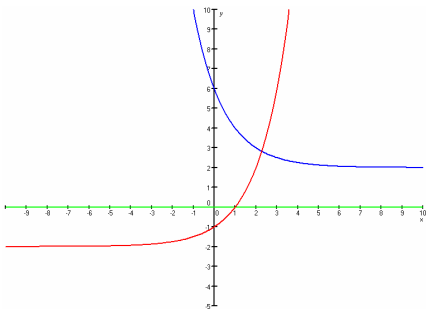
b. $N = 5$

c. $N = 1000$

d. $N = 100$

Opgave 6:

a. f: translatie over $(0,-2)$
g: translatie over $(2,2)$

b. 

c. $B_f = \langle -2, \rightarrow \rangle$

$B_g = \langle 2, \rightarrow \rangle$

d. $g(4) = 2\frac{1}{4}$

$2 < g(x) \leq 2\frac{1}{4}$

e. $y_1 = 2^x - 2$ en $y_2 = (\frac{1}{2})^{x-2} + 2$

intersect geeft: $x = 2{,}27$

dus $x \leq 2{,}27$

f. $p \leq -2$

g. $f(3) = 6$ en $g(3) = 2{,}5$

$AB = 6 - 2{,}5 = 3{,}5$

h. $y_3 = 7$

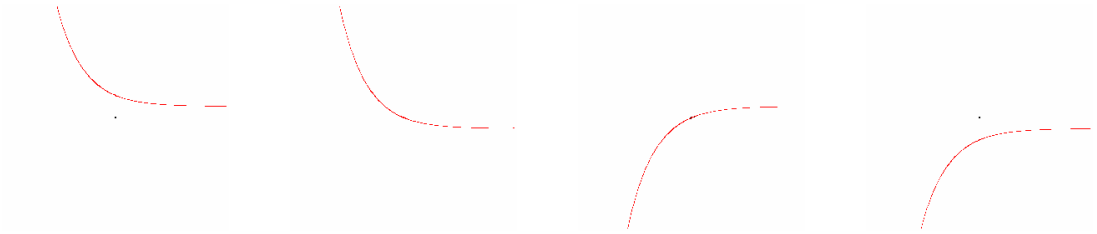
y_1 en y_3 intersect geeft $x = 3{,}17$

y_2 en y_3 intersect geeft $x = -0{,}32$

dus $CD = 3{,}17 - -0{,}32 = 3{,}49$

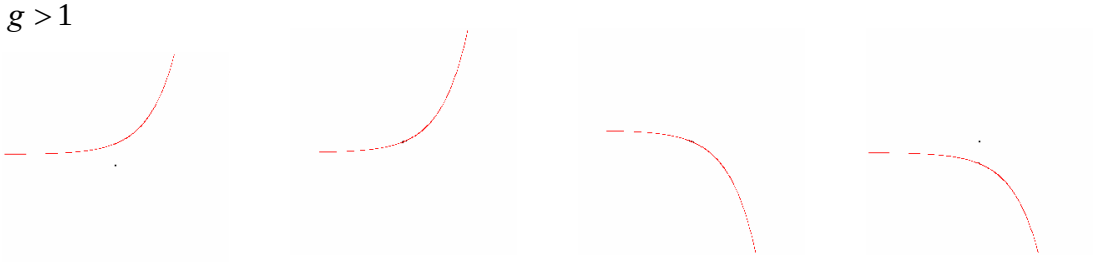
Opgave 7:

$0 < g < 1$



$a > 0\,,\, b > 0$ $a > 0\,,\, b < 0$ $a < 0\,,\, b > 0$ $a < 0\,,\, b < 0$

$g > 1$



$a > 0\,,\, b > 0$ $a > 0\,,\, b < 0$ $a < 0\,,\, b > 0$ $a < 0\,,\, b < 0$

Opgave 8:

a. $2^{x+1} = 64$

$2^{x+1} = 2^6$

$x + 1 = 6$

$x = 5$

b. $2^{x-3} = \frac{1}{8}$

$2^{x-3} = \dfrac{1}{2^3}$

$2^{x-3} = 2^{-3}$
$x - 3 = -3$
$x = 0$

c. $3^{4x-1} = \frac{1}{27}\sqrt{3}$
$3^{4x-1} = \frac{1}{3^3} \cdot 3^{\frac{1}{2}}$
$3^{4x-1} = 3^{-2\frac{1}{2}}$
$4x - 1 = -2\frac{1}{2}$
$4x = -1\frac{1}{2}$
$x = -\frac{3}{8}$

d. $5^{-x+6} = 625$
$5^{-x+6} = 5^4$
$-x + 6 = 4$
$-x = -2$
$x = 2$

e. $(\frac{1}{3})^x - 2 = 25$
$(3^{-1})^x = 27$
$3^{-x} = 3^3$
$-x = 3$
$x = -3$

f. $5 \cdot (\frac{1}{2})^x + 11 = 91$
$5 \cdot (\frac{1}{2})^x = 80$
$(\frac{1}{2})^x = 16$
$(2^{-1})^x = 2^4$
$2^{-x} = 2^4$
$-x = 4$
$x = -4$

g. $2^{x+3} = \sqrt{2}$
$2^{x+3} = 2^{\frac{1}{2}}$
$x + 3 = \frac{1}{2}$
$x = -2\frac{1}{2}$

h. $3^{x+2} = 9\sqrt{3}$
$3^{x+2} = 3^2 \cdot 3^{\frac{1}{2}}$
$3^{x+2} = 3^{2\frac{1}{2}}$
$x + 2 = 2\frac{1}{2}$
$x = \frac{1}{2}$

i. $4^{2x-1} = 64$
$4^{2x-1} = 4^3$
$2x - 1 = 3$
$2x = 4$
$x = 2$

Opgave 9:

a. $2^{3x+5} = 16\sqrt{2}$

$2^{3x+5} = 2^4 \cdot 2^{\frac{1}{2}}$

$2^{3x+5} = 2^{4\frac{1}{2}}$

$3x + 5 = 4\frac{1}{2}$

$3x = -\frac{1}{2}$

$x = -\frac{1}{6}$

b. $3^{4x} = \frac{1}{81} \cdot \sqrt[4]{9}$

$3^{4x} = \frac{1}{3^4} \cdot \sqrt[4]{3^2}$

$3^{4x} = 3^{-4} \cdot 3^{\frac{2}{4}}$

$3^{4x} = 3^{-3\frac{1}{2}}$

$4x = -3\frac{1}{2}$

$x = -\frac{7}{8}$

c. $3 \cdot 5^{2x-1} = 0{,}6$

$5^{2x-1} = 0{,}2$

$5^{2x-1} = \frac{1}{5}$

$5^{2x-1} = 5^{-1}$

$2x - 1 = -1$

$2x = 0$

$x = 0$

d. $3^{3x-3} = \frac{1}{3} \cdot \sqrt[4]{3}$

$3^{3x-3} = 3^{-1} \cdot 3^{\frac{1}{4}}$

$3^{3x-3} = 3^{-\frac{3}{4}}$

$3x - 3 = -\frac{3}{4}$

$3x = 2\frac{1}{4}$

$x = \frac{3}{4}$

e. $3 \cdot (\frac{1}{2})^{x-1} - 1 = -0{,}25$

$3 \cdot (\frac{1}{2})^{x-1} = 0{,}75$

$(\frac{1}{2})^{x-1} = 0{,}25$

$(\frac{1}{2})^{x-1} = \frac{1}{4}$

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

$x - 1 = 2$

$x = 3$

f. $3 \cdot 5^{2x+1} = 75\sqrt{5}$

$5^{2x+1} = 25\sqrt{5}$

$5^{2x+1} = 5^2 \cdot 5^{\frac{1}{2}}$

$5^{2x+1} = 5^{2\frac{1}{2}}$

$2x + 1 = 2\frac{1}{2}$

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

$x = \frac{3}{4}$

g. $2^{4x-1} = 2^{2x-3}$

$4x - 1 = 2x - 3$

$2x = -2$

$x = -1$

h. $3^{x^2} = 3^{x+6}$

$x^2 = x + 6$

$x^2 - x - 6 = 0$

$(x-3)(x+2) = 0$

$x = 3 \quad \vee \quad x = -2$

i. $4^{|2x+1|} = 16$

$4^{|2x+1|} = 4^2$

$|2x+1| = 2$

$2x + 1 = 2 \quad \vee \quad 2x + 1 = -2$

$2x = 1 \quad \vee \quad 2x = -3$

$x = \frac{1}{2} \quad \vee \quad x = -1\frac{1}{2}$

Opgave 10:

a. $3^{x-4} < 3\sqrt{3}$

$3^{x-4} < 3 \cdot 3^{\frac{1}{2}}$

$3^{x-4} < 3^{1\frac{1}{2}}$

$x - 4 < 1\frac{1}{2}$

$x < 5\frac{1}{2}$

b. $0{,}2^x + 5 \geq 6$

$0{,}2^x \geq 1$

$0{,}2^x \geq 0{,}2^0$

$x \leq 0$

c. $5 - 2^{x+1} > 4\frac{1}{2}$

$-2^{x+1} > -\frac{1}{2}$

$2^{x+1} < \frac{1}{2}$

$2^{x+1} < 2^{-1}$

$x + 1 < -1$

$x < -2$

Opgave 11:

$2^{4x-1} = 4^{x-3}$

$2^{4x-1} = (2^2)^{x-3}$

$2^{4x-1} = 2^{2x-6}$

$4x - 1 = 2x - 6$

$2x = -5$

$x = -2\frac{1}{2}$

Opgave 12:

a. $2^{x+1} + 2^x = 48$

$2 \cdot 2^x + 2^x = 48$ want de regel $a^p \cdot a^q = a^{p+q}$ gebruik je nu van rechts naar links

b. $2 \cdot 2^x + 1 \cdot 2^x = 48$

$3 \cdot 2^x = 48$

$2^x = 16$

$2^x = 2^4$

$x = 4$

Opgave 13:

a. $2^{x+1} = 4^{3x+1}$

$2^{x+1} = (2^2)^{3x+1}$

$2^{x+1} = 2^{6x+2}$

$x + 1 = 6x + 2$

$-5x = 1$

$x = -\frac{1}{5}$

b. $4^{x-1} = 8^{3x-3}$

$(2^2)^{x-1} = (2^3)^{3x-3}$

$2^{2x-2} = 2^{9x-9}$

$2x - 2 = 9x - 9$

$-7x = -7$

$x = 1$

c. $2^{x^2} = (\frac{1}{4})^x$

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

$2^{x^2} = (2^{-2})^x$

$2^{x^2} = 2^{-2x}$

$x^2 = -2x$

$x^2 + 2x = 0$

$x(x + 2) = 0$

$x = 0 \quad \vee \quad x = -2$

d. $25^{x-3} = 5 \cdot 5^{2-x}$

$(5^2)^{x-3} = 5^{3-x}$

$5^{2x-6} = 5^{3-x}$

$2x - 6 = 3 - x$

$3x = 9$

$x = 3$

e. $27^x = 3 \cdot 9^{2x}$

$(3^3)^x = 3 \cdot (3^2)^{2x}$

$3^{3x} = 3 \cdot 3^{4x}$

$3^{3x} = 3^{4x+1}$

$3x = 4x + 1$

$-x = 1$

$x = -1$

f. $0{,}5^x = 0{,}25 \cdot 2^x$

$(\frac{1}{2})^x = \frac{1}{4} \cdot 2^x$

$(2^{-1})^x = \dfrac{1}{2^2} \cdot 2^x$

$2^{-x} = 2^{-2} \cdot 2^x$

$2^{-x} = 2^{x-2}$

$-x = x - 2$

$-2x = -2$

$x = 1$

Opgave 14:

a. $3^{x+2} + 3^x = 810$

$3^2 \cdot 3^x + 3^x = 810$

$9 \cdot 3^x + 3^x = 810$

$10 \cdot 3^x = 810$

$3^x = 81$

$3^x = 3^4$

$x = 4$

b. $2^{x-1} + 2^{x+1} = 10$

$2^{-1} \cdot 2^x + 2^1 \cdot 2^x = 10$

$\frac{1}{2} \cdot 2^x + 2 \cdot 2^x = 10$

$2\frac{1}{2} \cdot 2^x = 10$

$2^x = 4$

$2^x = 2^2$

$x = 2$

c. $2^{x+3} - 2^x = \frac{7}{8}$

$2^3 \cdot 2^x - 2^x = \frac{7}{8}$

$8 \cdot 2^x - 2^x = \frac{7}{8}$

$7 \cdot 2^x = \frac{7}{8}$

$2^x = \frac{1}{8}$

$2^x = \dfrac{1}{2^3}$

$2^x = 2^{-3}$

$x = -3$

d. $3^{x+2} = 24 + 3^x$

$3^2 \cdot 3^x - 3^x = 24$

$9 \cdot 3^x - 3^x = 24$

$8 \cdot 3^x = 24$

$3^x = 3$

$x = 1$

e. $3^x - 3^{x-1} = 2\sqrt{3}$

$3^x - 3^{-1} \cdot 3^x = 2\sqrt{3}$

$3^x - \frac{1}{3} \cdot 3^x = 2\sqrt{3}$

$\frac{2}{3} \cdot 3^x = 2\sqrt{3}$

$3^x = 3\sqrt{3}$

$3^x = 3^1 \cdot 3^{\frac{1}{2}}$

$3^x = 3^{1\frac{1}{2}}$

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

f. $5^{x-1} + 5^{x-2} = 6\sqrt{5}$

$5^{-1} \cdot 5^x + 5^{-2} \cdot 5^x = 6\sqrt{5}$

$\frac{1}{5} \cdot 5^x + \frac{1}{25} \cdot 5^x = 6\sqrt{5}$

$\frac{6}{25} \cdot 5^x = 6\sqrt{5}$

$5^x = 25\sqrt{5}$

$5^x = 5^2 \cdot 5^{\frac{1}{2}}$

$5^x = 5^{2\frac{1}{2}}$

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

Opgave 15:

a. $3^{x+1} = 9^{x+2}$

$3^{x+1} = (3^2)^{x+2}$

$3^{x+1} = 3^{2x+4}$

$x + 1 = 2x + 4$

$-x = 3$

$x = -3$

b. $3^{x+1} - 3^{x-1} = 8\sqrt{3}$

$3^1 \cdot 3^x - 3^{-1} \cdot 3^x = 8\sqrt{3}$

$3 \cdot 3^x - \frac{1}{3} \cdot 3^x = 8\sqrt{3}$

$\frac{8}{3} \cdot 3^x = 8\sqrt{3}$

$3^x = 3\sqrt{3}$

$3^x = 3^1 \cdot 3^{\frac{1}{2}}$

$3^x = 3^{1\frac{1}{2}}$

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

c. $3^{x^2} = (\frac{1}{3})^{x-6}$

$3^{x^2} = (3^{-1})^{x-6}$

$3^{x^2} = 3^{-x+6}$

$x^2 = -x + 6$

$x^2 + x - 6 = 0$

$(x + 3)(x - 2) = 0$

$x = -3 \quad \vee \quad x = 2$

d. $5^x + 5^{x+1} = \frac{6}{25}$

$5^x + 5^1 \cdot 5^x = \frac{6}{25}$

$6 \cdot 5^x = \frac{6}{25}$

$5^x = \frac{1}{25}$

$5^x = \dfrac{1}{5^2}$

$5^x = 5^{-2}$

$x = -2$

e. $5^{x^2+5} = 125^{x+1}$

$5^{x^2+5} = (5^3)^{x+1}$

$5^{x^2+5} = 5^{3x+3}$

$x^2 + 5 = 3x + 3$

$x^2 - 3x + 2 = 0$

$(x-1)(x-2) = 0$

$x = 1 \quad \vee \quad x = 2$

f. $2^{x+2} - (\frac{1}{2})^{-x+1} = 28$

$2^2 \cdot 2^x - (2^{-1})^{-x+1} = 28$

$4 \cdot 2^x - 2^{x-1} = 28$

$4 \cdot 2^x - 2^{-1} \cdot 2^x = 28$

$4 \cdot 2^x - \frac{1}{2} \cdot 2^x = 28$

$3\frac{1}{2} \cdot 2^x = 28$

$2^x = 8$

$2^x = 2^3$

$x = 3$

g. $4^{x^2+1} = 8^{x^2-1}$

$(2^2)^{x^2+1} = (2^3)^{x^2-1}$

$2^{2x^2+2} = 2^{3x^2-3}$

$2x^2 + 2 = 3x^2 - 3$

$-x^2 = -5$

$x^2 = 5$

$x = \sqrt{5} \quad \vee \quad x = -\sqrt{5}$

h. $2^{x+3} - 4^{\frac{1}{2}x-1} = 3\frac{7}{8}$

$2^3 \cdot 2^x - (2^2)^{\frac{1}{2}x-1} = \frac{31}{8}$

$8 \cdot 2^x - 2^{x-2} = \frac{31}{8}$

$8 \cdot 2^x - 2^{-2} \cdot 2^x = \frac{31}{8}$

$8 \cdot 2^x - \frac{1}{4} \cdot 2^x = \frac{31}{8}$

$7\frac{3}{4} \cdot 2^x = \frac{31}{8}$

$2^x = \frac{1}{2}$

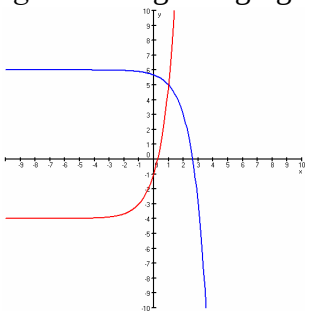
$2^x = 2^{-1}$

$x = -1$

Opgave 16:

a. f: translatie over $(-1,-4)$

g: vermenigvuldiging t.o.v. de x-as met -1, daarna translatie over $(1,6)$.

b. 

c. $B_f = \langle -4, \rightarrow \rangle$

$B_g = \langle \leftarrow, 6 \rangle$

d. $3^{x+1} - 4 \le 6 - 3^{x-1}$

$3^{x+1} + 3^{x-1} \le 10$

$3^1 \cdot 3^x + 3^{-1} \cdot 3^x \le 10$

$3 \cdot 3^x + \frac{1}{3} \cdot 3^x \le 10$

$3\frac{1}{3} \cdot 3^x \le 10$

$3^x \le 3$

$x \le 1$

e. $f(2\frac{1}{2}) = 3^{3\frac{1}{2}} - 4 = 3^3 \cdot 3^{\frac{1}{2}} - 4 = 27\sqrt{3} - 4$

$g(2\frac{1}{2}) = 6 - 3^{1\frac{1}{2}} = 6 - 3^1 \cdot 3^{\frac{1}{2}} = 6 - 3\sqrt{3}$

$AB = f(2\frac{1}{2}) - g(2\frac{1}{2}) = 27\sqrt{3} - 4 - (6 - 3\sqrt{3}) = 27\sqrt{3} - 4 - 6 + 3\sqrt{3} = 30\sqrt{3} - 10$

f. $f(x) - g(x) = 80$

$3^{x+1} - 4 - (6 - 3^{x-1}) = 80$

$3^{x+1} - 4 - 6 + 3^{x-1} = 80$

$3^1 \cdot 3^x + 3^{-1} \cdot 3^x = 90$

$3 \cdot 3^x + \frac{1}{3} \cdot 3^x = 90$

$\frac{10}{3} \cdot 3^x = 90$

$3^x = 27$

$3^x = 3^3$

$x = 3$

g. $g(x) - f(x) = p$

$6 - 3^{x-1} - (3^{x+1} - 4) = p$

$6 - 3^{x-1} - 3^{x+1} + 4 = p$

$-3^{x-1} - 3^{x+1} = p - 10$

$3^{x-1} + 3^{x+1} = -p + 10$

$3^{-1} \cdot 3^x + 3^1 \cdot 3^x = -p + 10$

$\frac{1}{3} \cdot 3^x + 3 \cdot 3^x = -p + 10$

$3\frac{1}{3} \cdot 3^x = -p + 10$

$3^x = -\frac{3}{10}p + 3$

$3^x > 0$ voor iedere x dus er zijn geen oplossingen als $-\frac{3}{10}p + 3 \leq 0$

$-\frac{3}{10}p \leq -3$

$p \geq 10$

5.2 Exponentiële groei.

Opgave 17:

a. $30 \cdot 2 = 60$ minuten

b. na 4 minuten 2 leerlingen
na 8 minuten $2 + 4 = 6$ leerlingen
na 12 minuten $6 + 8 = 14$ leerlingen
na 16 minuten $14 + 16 = 30$ leerlingen
dus na 16 minuten zijn alle leerlingen op de hoogte

Opgave 18:

a. $l = 0{,}2t + 3$

b. $l(0) = 3$ en $l(1) = 3{,}2$ dus $\frac{3{,}2 - 3}{3} \cdot 100\% = 6{,}7\%$

$l(9) = 4{,}8$ en $l(10) = 5$ dus $\frac{5 - 4{,}8}{4{,}8} \cdot 100\% = 4{,}2\%$

c. $\frac{3}{0{,}2} = 15$ dus na 15 dagen

Opgave 19:

a. $N = 9{,}8 \cdot 1{,}045^t$

b. $N(6) = 12{,}8$ miljoen

c. $y_1 = 9{,}8 \cdot 1{,}045^x$ en $y_2 = 16$
intersect geeft $t = 11{,}1$ dus in 2015

d. $y_1 = 9{,}8 \cdot 1{,}045^x$ en $y_2 = 19{,}6$
intersect geeft $t = 15{,}7$ dus in 2019

Opgave 20:

$g = 1 + \frac{17}{100} = 1{,}17$

Opgave 21:

a. $g = 1 + \frac{12{,}7}{100} = 1{,}127$

b. $g = 1 - \frac{6{,}8}{100} = 0{,}932$

c. 73,5%

d. 15,5%

e. 142%

f. $g = 1 - \frac{0{,}7}{100} = 0{,}993$

Opgave 22:

a. $N_C = 1310 \cdot 1{,}006^t$

b. $N_I = 1080 \cdot 1{,}013^t$

c. $N_C(5) = 1350$ miljoen

$N_I(5) = 1152$ miljoen

d. $y_1 = 1310 \cdot 1{,}006^x$ en $y_2 = 1080 \cdot 1{,}013^x$
intersect geeft $x = 27{,}8$ dus in 2032

e. $N_I(11) = 1244{,}9$ en $N_I(12) = 1261{,}1$ dus in 2016

Opgave 23:

a. $0{,}6^4 = 0{,}1296$ dus 12,96%
$0{,}7^4 = 0{,}2401$ dus 24,01%

b. $y_1 = 0{,}6^x$ en $y_2 = 0{,}01$
intersect geeft $x = 9{,}0$
$0{,}7^9 = 0{,}04$ dus 4% blauw licht, dus 4 keer zo veel

Opgave 24:

a.

t	0	1	2	3	4	5
N	2	18	162	1458	13122	118098

b. 81

c. minder, $4{,}5 \cdot 4{,}5 = 20{,}25$

Opgave 25:

a. $g_{kwartier} = 1{,}12$
$g_{uur} = 1{,}12^4 = 1{,}57$ dus 57%

b. $g_{5\,\min} = 1{,}12^{\frac{1}{3}} = 1{,}038$ dus 3,8%

Opgave 26:

$g_{dag} = 0{,}84$

a. $g_{week} = 0{,}84^7 = 0{,}295$

b. $g_{uur} = 0{,}84^{\frac{1}{24}} = 0{,}993$ dus 0,7%

Opgave 27:

a. $g_{week} = 1{,}13^7 = 6{,}27$ dus 527%

b. $g_{4\,uur} = 1{,}3^{\frac{1}{6}} = 1{,}045$ dus 4,5%

Opgave 28:

a. $g_{uur} = 0{,}805$
$g_{kwartier} = 0{,}805^{\frac{1}{4}} = 0{,}947$ dus 5,3%

b. $g_{jaar} = 1{,}086$
$1{,}086^{25} = 7{,}87$ dus 687%

c. $g_{week} = 2{,}8$
$g_{dag} = 2{,}8^{\frac{1}{7}} = 1{,}158$ dus 15,8%

Opgave 29:

a. $1{,}05^7 = 1{,}407$ dus 40,7%

b. $1{,}5^7 = 17{,}1$

c. $0{,}8^{\frac{1}{4}} = 0{,}946$ dus 5,4%

d. $0{,}7^{\frac{1}{4}} = 0{,}915$

Opgave 30:

a. $g^{20} = 9$

$g = \sqrt[20]{9} = 1{,}116$ dus 11,6%

Opgave 31:

a. $g^{10} = 0{,}05$

$g = \sqrt[10]{0{,}05} = 0{,}741$ dus 25,9%

b. $g^{20} = 12$

$g = \sqrt[20]{12} = 1{,}132$ dus 13,2%

c. $\frac{14000}{12} = 1167$

$\frac{1167}{0{,}05} = 23333$

Opgave 32:

a. $g^4 = \frac{300000}{50000} = 6$

b. $g = \sqrt[4]{6} = 1{,}565$

Opgave 33:

$g^7 = \frac{4100}{1600} = 2{,}5625$

$g = \sqrt[7]{2{,}5625} = 1{,}144$

$b = \frac{1600}{1{,}144^3} = 1069$

$N = 1069 \cdot 1{,}144^t$

Opgave 34:

$g^6 = \frac{2500}{1000} = 2{,}5$

$g = \sqrt[6]{2{,}5} = 1{,}165$

$b = \frac{1000}{1{,}165^4} = 543$

$N = 543 \cdot 1{,}165^t$

Opgave 35:

a. $g^4 = \frac{11}{31} = 0{,}355$

$g = \sqrt[4]{0{,}355} = 0{,}772$

$b = \frac{31}{0{,}772^3} = 67$

$A = 67 \cdot 0{,}772^t$

b. 67 mm²

c. $t = \frac{60}{24} = 2{,}5$

$A(2{,}5) = 35$ mm²

Opgave 36:

a. $g^3 = \frac{8}{10} = 0{,}8$

$g = \sqrt[3]{0{,}8} = 0{,}928$ dus 7,2%

b. $b = \frac{10}{0{,}928^6} = 15{,}6$ knopen

c. $15{,}6 \cdot 0{,}928^{30} = 1{,}7$ knopen

d. $y_1 = 15{,}6 \cdot 0{,}928^x$ en $y_2 = 1$

intersect geeft $x = 36{,}8$ dus na 37 minuten

5.3 Logaritmen

Opgave 37:

a. $2^3 = 8$

b. $2^{-2} = \frac{1}{4}$

c. $2^{\frac{1}{2}} = \sqrt{2}$

d. $3^2 = 9$

e. $3^{-3} = \frac{1}{27}$

f. $3^{\frac{1}{5}} = \sqrt[5]{3}$

Opgave 38:

a. ${}^5\log 125 = {}^5\log 5^3 = 3$

b. ${}^{10}\log 0{,}1 = {}^{10}\log \frac{1}{10} = {}^{10}\log 10^{-1} = -1$

c. ${}^2\log 4 = {}^2\log 2^2 = 2$

d. ${}^7\log 49 = {}^7\log 7^2 = 2$

e. ${}^2\log \sqrt{2} = {}^2\log 2^{\frac{1}{2}} = \frac{1}{2}$

f. ${}^2\log 0{,}5 = {}^2\log \frac{1}{2} = {}^2\log 2^{-1} = -1$

g. ${}^4\log 0{,}25 = {}^4\log \frac{1}{4} = {}^4\log 4^{-1} = -1$

h. ${}^4\log 4 = {}^4\log 4^1 = 1$

i. ${}^4\log 1 = {}^4\log 4^0 = 0$

Opgave 39:

a. ${}^2\log 64\sqrt{2} = {}^2\log(2^6 \cdot 2^{\frac{1}{2}}) = {}^2\log 2^{6\frac{1}{2}} = 6\frac{1}{2}$

b. ${}^3\log \frac{1}{9}\sqrt{3} = {}^3\log(\frac{1}{3^2} \cdot 3^{\frac{1}{2}}) = {}^3\log(3^{-2} \cdot 3^{\frac{1}{2}}) = {}^3\log 3^{-1\frac{1}{2}} = -1\frac{1}{2}$

c. ${}^3\log 3^{21{,}5} = 21{,}5$

d. ${}^5\log \frac{1}{125} = {}^5\log \frac{1}{5^3} = {}^5\log 5^{-3} = -3$

e. ${}^{\frac{1}{3}}\log \frac{1}{27} = {}^{\frac{1}{3}}\log(\frac{1}{3})^3 = 3$

f. ${}^{\frac{1}{2}}\log \frac{1}{4} = {}^{\frac{1}{2}}\log(\frac{1}{2})^2 = 2$

g. ${}^2\log(\frac{1}{32} \cdot \sqrt[3]{2}) = {}^2\log(\frac{1}{2^5} \cdot 2^{\frac{1}{3}}) = {}^2\log(2^{-5} \cdot 2^{\frac{1}{3}}) = {}^2\log 2^{-4\frac{2}{3}} = -4\frac{2}{3}$

h. ${}^5\log 1 = {}^5\log 5^0 = 0$

i. ${}^3\log(81 \cdot \sqrt[5]{27}) = {}^3\log(3^4 \cdot \sqrt[5]{3^3}) = {}^3\log(3^4 \cdot 3^{\frac{3}{5}}) = {}^3\log 3^{4\frac{3}{5}} = 4\frac{3}{5}$

Opgave 40:

a. ${}^2\log 2^8 = 8$ dus ${}^2\log 256 = 8$

b. ${}^3\log 3^{-3} = -3$ dus ${}^3\log \frac{1}{3^3} = -3$ dus ${}^3\log \frac{1}{27} = -3$

c. ${}^5\log 5^{\frac{1}{2}} = \frac{1}{2}$ dus ${}^5\log \sqrt{5} = \frac{1}{2}$

Opgave 41:

a. $^3\log(x+2)=2$

$x+2=3^2$

$x+2=9$

$x=7$

b. $1+^{\frac{1}{2}}\log x=4$

$^{\frac{1}{2}}\log x=3$

$x=(\frac{1}{2})^3=\frac{1}{8}$

c. $^3\log(2x+1)=4$

$2x+1=3^4$

$2x+1=81$

$2x=80$

$x=40$

d. $5+^4\log x=3$

$^4\log x=-2$

$x=4^{-2}=\frac{1}{4^2}=\frac{1}{16}$

e. $^{\frac{1}{2}}\log(x-1)=3$

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

$x-1=\frac{1}{8}$

$x=1\frac{1}{8}$

f. $^2\log(x^2-4)=5$

$x^2-4=2^5$

$x^2-4=32$

$x^2=36$

$x=6 \quad \vee \quad x=-6$

Opgave 42:

a. $4\cdot{}^3\log x=2$

$^3\log x=\frac{1}{2}$

$x=3^{\frac{1}{2}}=\sqrt{3}$

b. $^3\log(4x-1)=-2$

$4x-1=3^{-2}$

$4x-1=\frac{1}{3^2}$

$4x-1=\frac{1}{9}$

$4x=1\frac{1}{9}$

$x=\frac{10}{36}=\frac{5}{18}$

c. $3+^2\log x=-1$

$^2\log x=-4$

$x=2^{-4}=\frac{1}{2^4}=\frac{1}{16}$

d. $^5\log(3x+2)=1$

$3x+2=5^1$

$3x+2=5$

$3x=3$

$x=1$

e. $^3\log(0{,}4x-5)=2$

$0{,}4x-5=3^2$

$0{,}4x-5=9$

$0{,}4x=14$

$x=35$

f. $4+2\cdot {}^2\log x=7$

$2\cdot {}^2\log x=3$

$^2\log x=1\frac{1}{2}$

$x=2^{1\frac{1}{2}}=2^1\cdot 2^{\frac{1}{2}}=2\sqrt{2}$

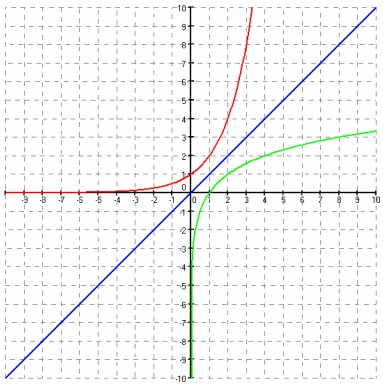
Opgave 43:

a.

x	-3	-2	-1	0	1	2	3
$y=2^x$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	1	2	4	8

x	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	1	2	4	8
$y={}^2\log x$	-3	-2	-1	0	1	2	3

b.



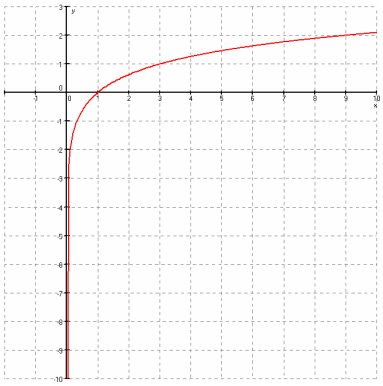
c. spiegeling in de lijn $y=x$

Opgave 44:

a.

x	$\frac{1}{9}$	$\frac{1}{3}$	1	3	9
$f(x)$	-2	-1	0	1	2

b.



c. ${}^3\log x = 1\frac{1}{2}$

$x = 3^{1\frac{1}{2}} = 3\sqrt{3}$

dus $0 < x \le 1\frac{1}{2}$

d. $f(\sqrt{3}) = {}^3\log\sqrt{3} = \frac{1}{2}$

$f(27) = {}^3\log 27 = 3$

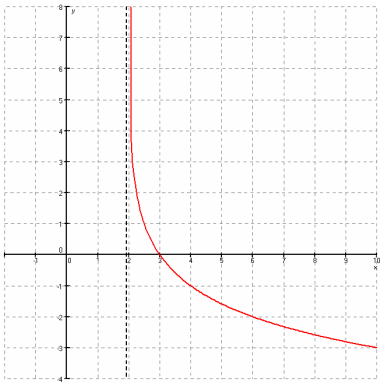
dus $\frac{1}{2} \le f(x) \le 3$

Opgave 45:

a.

x	6	4	3	$2\frac{1}{2}$	$2\frac{1}{4}$
$f(x)$	-2	-1	0	1	2

b.



c. $f(2\frac{1}{8}) = {}^{\frac{1}{2}}\log\frac{1}{8} = 3$ dus $f(x) \le 3$

d. ${}^{\frac{1}{2}}\log(x-2) = -3$

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

$x - 2 = 8$

$x = 10$

dus $2 < x \le 10$

Opgave 46:

$2^{{}^2\log 8} = 2^3 = 8$

$3^{{}^3\log 9} = 3^2 = 9$

$2^{\,^2\log\frac{1}{2}} = 2^{-1} = \frac{1}{2}$

Opgave 47:

a. $\log 100 = 2$

$\log 1000 = 3$

b. $g = 10$

Opgave 48:

a. $^3\log 5 = \dfrac{\log 5}{\log 3} = 1{,}46$

b. $^{\frac{1}{7}}\log 18 = \dfrac{\log 18}{\log \frac{1}{7}} = -1{,}49$

c. $^2\log 20 - {}^2\log 6 = \dfrac{\log 20}{\log 2} - \dfrac{\log 6}{\log 2} = 1{,}74$

d. $^{\frac{1}{3}}\log 10 + \log\frac{1}{3} = \dfrac{\log 10}{\log \frac{1}{3}} + \dfrac{\log \frac{1}{3}}{\log 10} = -2{,}57$

e. $3 \cdot {}^2\log 7 = 3 \cdot \dfrac{\log 7}{\log 2} = 8{,}42$

f. $\dfrac{5}{^4\log 12} = \dfrac{5}{\frac{\log 12}{\log 4}} = 2{,}79$

Opgave 49:

a. $T(0,3)$

b. $T(-3,0)$

c. $V_{x-as,3}$

d. $D_f = \langle 0, \rightarrow \rangle$ V.A.: $x = 0$

$D_g = \langle 0, \rightarrow \rangle$ V.A.: $x = 0$

$D_h = \langle -3, \rightarrow \rangle$ V.A.: $x = -3$

$D_k = \langle 0, \rightarrow \rangle$ V.A.: $x = 0$

Opgave 50:

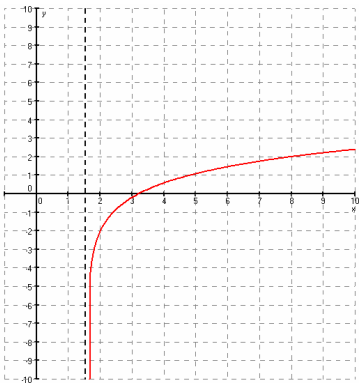
a. $5x - 8 > 0$

$5x > 8$

$x > 1{,}6$

$D_f = \langle 1{,}6; \rightarrow \rangle$

V.A.: $x = 1{,}6$



b. $-3 + {}^2\log(5x - 8) = 0$

$^2\log(5x - 8) = 3$

$5x - 8 = 2^3$

$5x - 8 = 8$

$5x = 16$

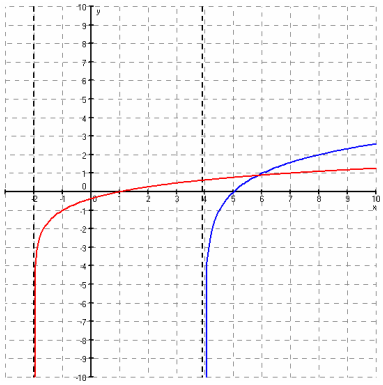
$x = 3{,}2$

$1{,}6 < x \le 3{,}2$

c. $f(8) = -3 + {}^{2}\log 32 = -3 + 5 = 2$

$f(x) \le 2$

Opgave 51:



a. $x + 2 > 0$

$x > -2$

$D_f = \langle -2, \rightarrow \rangle$

V.A.: $x = -2$

$x - 4 > 0$

$x > 4$

$D_g = \langle 4, \rightarrow \rangle$

V.A.: $x = 4$

b. $y_1 = -1 + \log(x+2)/\log(3)$

$y_2 = \log(x-4)/\log(2)$

Intersect geeft: $x = 5{,}83$ en $y = 0{,}87$

c. $4 < x \le 5{,}83$

Opgave 52:

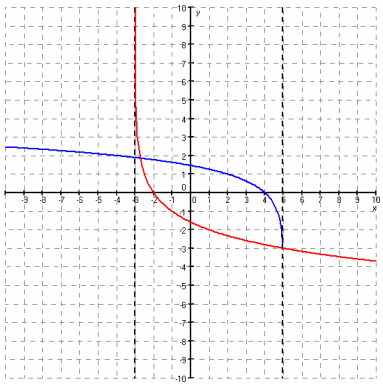
a. $T(5,-3)$ dus $D_f = \langle 5, \rightarrow \rangle$ en V.A.: $x = 5$

b. $T(-1,3)$ dus $D_g = \langle -1, \rightarrow \rangle$ en V.A.: $x = -1$

c. $V_{x-as,5}$ dan $T(2,0)$ dus $D_h = \langle 2, \rightarrow \rangle$ en V.A.: $x = 2$

d. $V_{x-as,-2}$ dan $T(0,-4)$ dus $D_k = \langle 0, \rightarrow \rangle$ en V.A.: $x = 0$

Opgave 53:



a. $D_f = \langle -3, \rightarrow \rangle$ en V.A.: $x = -3$

$-x + 5 > 0$

$-x > -5$

$x < 5$

$D_g = \langle \leftarrow, 5 \rangle$

V.A.: $x = 5$

b. ${}^{\frac{1}{2}}\log(x+3) = 5$

$x + 3 = (\frac{1}{2})^5$

$x + 3 = \frac{1}{32}$

$x = -2\frac{31}{32}$

c. $g(-4) = {}^{3}\log 9 = 2$

$g(x) \le 2$

d. ${}^{\frac{1}{2}}\log(x+3) = 1$

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

$x + 3 = \frac{1}{2}$

$x = -2\frac{1}{2}$

$x \leq -2\frac{1}{2}$

e. $y_1 = \log(x+3)/\log(0.5)$

$y_2 = \log(-x+5)/\log(3)$

Intersect geeft $x = -2{,}72 \quad \vee \quad x = 4{,}96$

$-2{,}72 \leq x \leq 4{,}96$

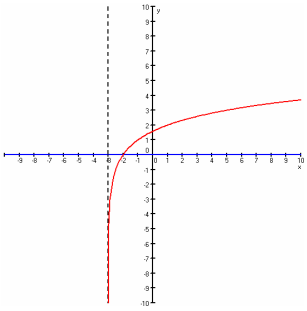
f. $y_3 = 2{,}5$

y_1 en y_3 intersect geeft: $x = -2{,}823$

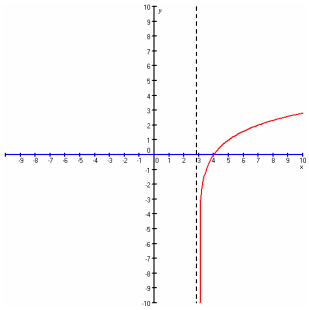
y_2 en y_3 intersect geeft: $x = -10{,}588$

$AB = -2{,}823 - -10{,}588 = 7{,}77$

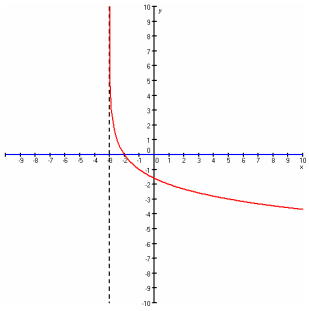
Opgave 54:



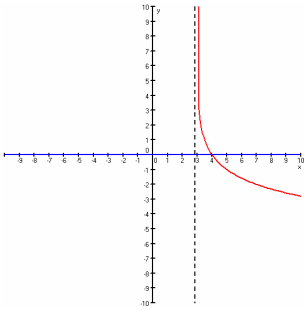
$a > 0\,;\, b > 0\,;\, g > 1$



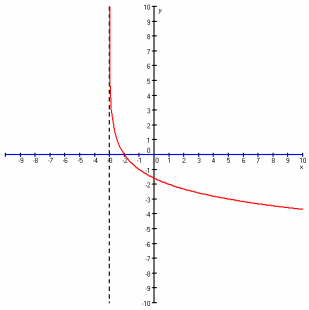
$a > 0\,;\, b < 0\,;\, g > 1$



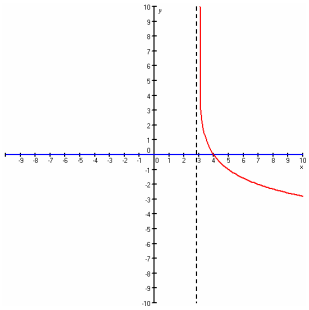
$a > 0\,;\, b > 0\,;\, g < 1$



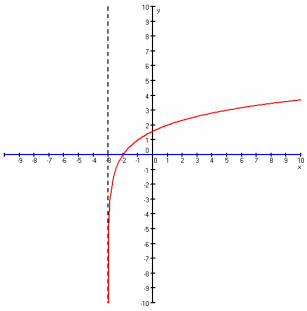
$a > 0\,;\, b < 0\,;\, g < 1$



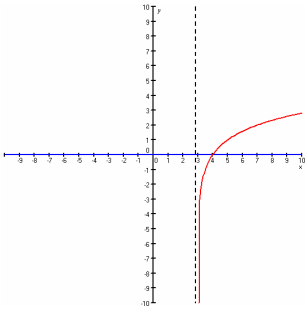
$a < 0\,;\, b > 0\,;\, g > 1$



$a < 0\,;\, b < 0\,;\, g > 1$



$a < 0\,;\, b > 0\,;\, g < 1$



$a < 0\,;\, b < 0\,;\, g < 1$

Opgave 55:

a. $21 = 1 + k \cdot \log 100$
$21 = 1 + k \cdot 2$
$20 = 2k$
$k = 10$

b. $DIN = 1 + 10 \cdot \log 400 = 27$

c. $1 + 10 \cdot \log ASA = 24$
$10 \cdot \log ASA = 23$
$\log ASA = 2{,}3$
$ASA = 200$

Opgave 56:

a. $R = 0{,}67 \cdot \log(1{,}5 \cdot 10^7) - 0{,}9 = 3{,}9$

b. $0{,}67 \cdot \log E - 0{,}9 = 9{,}3$
$0{,}67 \cdot \log E = 10{,}2$
$\log E = 15{,}22$
$E = 10^{15{,}22} = 1{,}7 \cdot 10^{15}$ kJ

c. $\frac{1{,}7 \cdot 10^{15}}{1{,}5 \cdot 10^7} = 1{,}1 \cdot 10^8$

Opgave 57:

Zie de tabel, als de geluidsintensiteit 10× zo groot is, dan is het aantal decibel 10 hoger.
Dus het aantal decibel van 10 leerlingen is 65.

Opgave 58:

Vrachtwagen: $10 \cdot \log \frac{I}{10^{-12}} = 65$

$\log \frac{I}{10^{-12}} = 6{,}5$

$\frac{I}{10^{-12}} = 3{,}16 \cdot 10^6$

$I = 3{,}16 \cdot 10^{-6}$

Trein: $10 \cdot \log \frac{I}{10^{-12}} = 72$

$\log \frac{I}{10^{-12}} = 7{,}2$

$\frac{I}{10^{-12}} = 1{,}58 \cdot 10^7$

$I = 1{,}58 \cdot 10^{-5}$

$I_{totaal} = I_v + I_t = 3{,}16 \cdot 10^{-6} + 1{,}58 \cdot 10^{-5} = 1{,}9 \cdot 10^{-5}$

$L = 10 \cdot \log \frac{1{,}9 \cdot 10^{-5}}{10^{-12}} = 72{,}8$

Dus het geluidsniveau stijgt met $72{,}8 - 65 = 7{,}8$ dB

Opgave 59:

a. stel $I_1 = 10^{-4}$

dan is $I_2 = \frac{I_1}{4} = \frac{10^{-4}}{4} = 2{,}5 \cdot 10^{-5}$

$L_1 = 10 \cdot \log \frac{10^{-4}}{10^{-12}} = 80$

$L_2 = 10 \cdot \log \frac{2{,}5 \cdot 10^{-5}}{10^{-12}} = 74$

Dus het geluidsniveau daalt inderdaad 6 dB.

b. De afstand wordt 2× verdubbeld, dus het geluidsniveau daalt met $2 \cdot 6 = 12$ dB.
Dus $85 - 12 = 73$ dB.

Opgave 60:

$10 \cdot \log \frac{I_1}{10^{-12}} = 80$ $\qquad$ $10 \cdot \log \frac{I_2}{10^{-12}} = 90$

$\log \frac{I_1}{10^{-12}} = 8$ $\qquad$ $\log \frac{I_2}{10^{-12}} = 9$

$\frac{I_1}{10^{-12}} = 10^8$ $\qquad$ $\frac{I_2}{10^{-12}} = 10^9$

$I_1 = 10^{-4}$ $\qquad$ $I_2 = 10^{-3}$

$\frac{I_2}{I_1} = \frac{10^{-3}}{10^{-4}} = 10$ dus I_2 geldt voor 50 boxen

Dus men mag er nog 45 bij plaatsen.

6.4 Toepassingen van logaritmen

Opgave 61:

a. $\frac{100000}{10} = 10000$

$\frac{100000}{0{,}002} = 50000000$

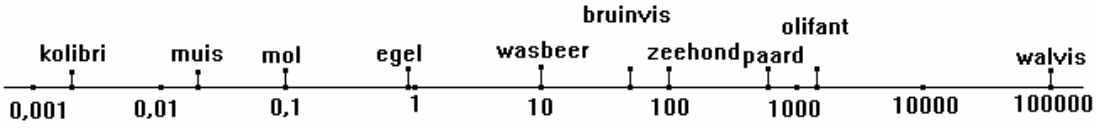
b. $100000\,\text{kg} = 10^8\,\text{g}$

$\frac{10^8}{10} = 10^7\,\text{cm} = 100000\,\text{m}$

c. $\frac{100000}{1000} = 100\,\text{mm} = 10\,\text{cm}$

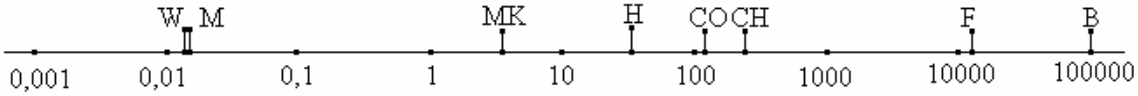
bezwaar: de eerste acht dieren liggen allemaal binnen 1 mm.

Opgave 62:



Opgave 63:

a.



b. Technopower: $10^{-0{,}04} = 0{,}91$

Allison: $10^{3{,}1} = 1259$

Opgave 64:

Mercurius: $\log 88 = 1{,}94$

Venus: $\log 225 = 2{,}35$

Aarde: $\log 365 = 2{,}56$

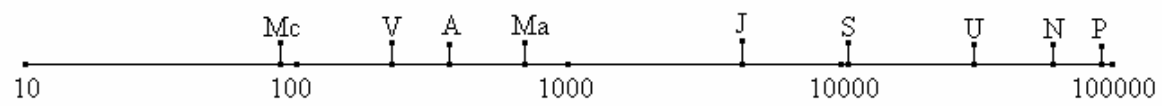
Mars: $\log 687 = 2{,}84$

Jupiter: $\log(11{,}86 \cdot 365) = 3{,}64$

Saturnus: $\log(29{,}46 \cdot 365) = 4{,}03$

Uranus: $\log(84{,}08 \cdot 365) = 4{,}49$

Pluto: $\log(248{,}4 \cdot 365) = 4{,}96$



Opgave 65:

a. $A = 1{,}3$ $B = 7{,}5$ $C = 23$ $D = 55$ $E = 150$ $F = 2400$

b. 550 , 210 , 9,5 , 2,4

c. $A = 1300$ $B = 7500$ $C = 23000$ $D = 55000$ $E = 150000$ $F = 2400000$

Opgave 66:

a. minimum: $1{,}1 \cdot 10^4 \cdot 1000 = 1{,}1 \cdot 10^7$ kg

maximum: $2{,}6 \cdot 10^4 \cdot 1000 = 2{,}6 \cdot 10^7$ kg

b. schol: $5{,}3 \cdot 10^4$

tarbot: $2{,}9 \cdot 10^3$

dus: $\dfrac{5{,}3 \cdot 10^4}{2{,}9 \cdot 10^3} = 18$ keer

c. $\dfrac{1{,}3 \cdot 10^4 - 2{,}6 \cdot 10^4}{2{,}6 \cdot 10^4} \cdot 100\% = -50\%$

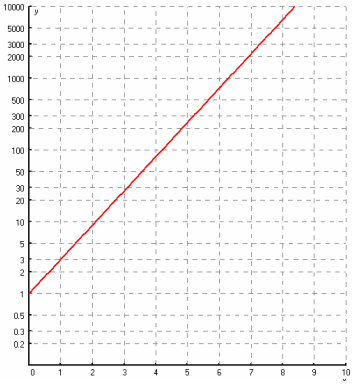
d. $6{,}5 \cdot 10^4 \cdot 1000 : 1000000 = 65\,\text{cm}$

Opgave 67:

a.

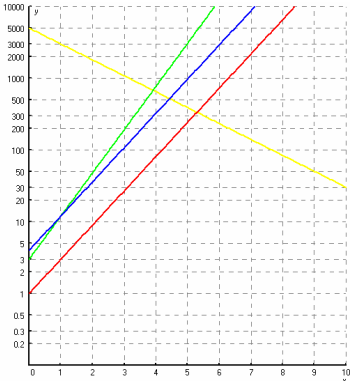
x	0	2	4	6	8
3^x	1	9	81	729	6561

b.



De punten liggen op logaritmisch papier op een rechte lijn.

c.



Opgave 68:

a. $t = 1 \quad N = 30$

$t = 7 \quad N = 400$

$g^6 = \frac{400}{30}$ dus $g = \sqrt[6]{\frac{400}{30}} = 1{,}54$

$30 = b \cdot 1{,}54^1$

$b = \frac{30}{1{,}54^1} = 19$

$N = 19 \cdot 1{,}54^t$

b. $t = 2 \quad N = 100$

$t = 6 \quad N = 20$

$g^4 = \frac{20}{100} = 0{,}2$ dus $g = \sqrt[4]{0{,}2} = 0{,}67$

$100 = b \cdot 0{,}76^2$

$b = \frac{100}{0{,}67^2} = 224$

$N = 224 \cdot 0{,}67^t$

Opgave 69:

a. planten B en C

plant B: $t = 0 \quad l = 60$

$t = 21 \quad l = 200$

$g^{21} = \frac{200}{60} = 3{,}33$ dus $g = \sqrt[21]{3{,}33} = 1{,}059$

$l_B = 60 \cdot 1{,}059^t$

plant C: $t = 5 \quad l = 40$

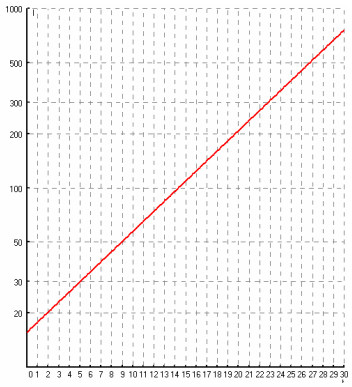
$t = 21 \quad l = 200$

$g^{16} = \frac{200}{40} = 5$ dus $g = \sqrt[16]{5} = 1{,}106$

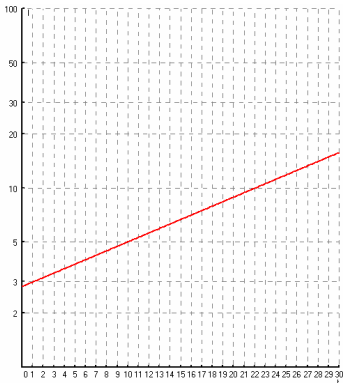
$b = \frac{40}{1{,}106^5} = 24{,}2$

$l_C = 24{,}2 \cdot 1{,}106^t$

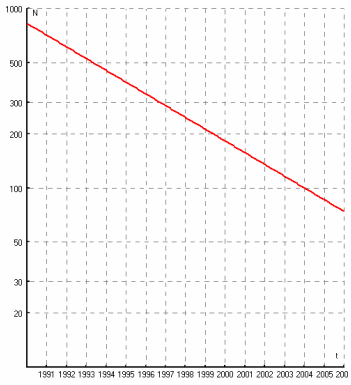
b.



c.



Opgave 70:

a. 

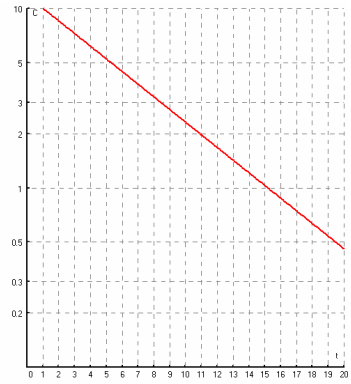
De punten liggen op logaritmisch papier op een rechte lijn.

b. $g^{14} = \frac{75}{610} = 0{,}123$ dus $g = \sqrt[14]{0{,}123} = 0{,}86$

$b = \frac{610}{0{,}86^2} = 825$

$N = 825 \cdot 0{,}86^t$

Opgave 71:

a. 

b. $g^{18} = \frac{0{,}5}{10} = 0{,}05$ dus $g = \sqrt[18]{0{,}05} = 0{,}85$

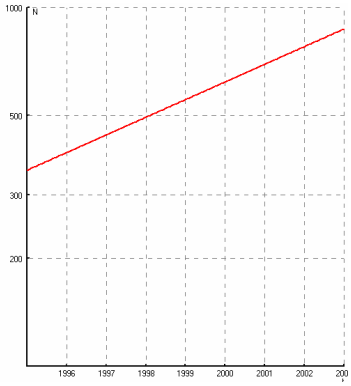
$b = \frac{10}{0{,}85} = 11{,}8$

$C = 11{,}8 \cdot 0{,}85^t$

c. $C(0) = 11{,}8$

$\frac{60}{11{,}8} = 5{,}1 \text{ liter}$

Opgave 72:

a. 

b. de eerste twee waarden liggen niet op de rechte lijn, dus vanaf 1997.

c. $g^6 = \frac{870}{441} = 1{,}97$ dus $g = \sqrt[6]{1{,}97} = 1{,}12$

$b = \frac{441}{1{,}12^2} = 352$

$N = 352 \cdot 1{,}12^t$

Opgave 73:

a. $21{,}7 \cdot 1{,}026^t = 43{,}4$

$1{,}026^t = 2$

$t = \frac{\log 2}{\log 1{,}026} = 27$ dus na 27 jaar

b. $21{,}7 \cdot 1{,}026^t = 39{,}2$

$1{,}026^t = 1{,}806$

$t = \frac{\log 1{,}806}{\log 1{,}026} = 23$ dus in 2027, dus na 27 jaar

c. de verdubbelingstijd is onafhankelijk van je begintijdstip (dus je beginhoeveelheid).

Opgave 74:

$g_{jaar} = 0{,}88$ dus $g_{maand} = 0{,}88^{\frac{1}{12}}$

halveringstijd: $\left(0{,}88^{\frac{1}{12}}\right)^t = \frac{1}{2}$

$t = \frac{\log \frac{1}{2}}{\log 0{,}88^{\frac{1}{12}}}$

Opgave 75:

a. $g = 1{,}131$

$1{,}131^t = 2$

$t = \frac{\log 2}{\log 1{,}131} = 5{,}63$ jaar , dus 68 maanden

b. $g = 0{,}915$

$0{,}915^t = \frac{1}{2}$

$t = \frac{\log \frac{1}{2}}{\log 0{,}915} = 7{,}8$ weken , dus 55 dagen

Opgave 76:

a. $1{,}011^t = 2$

$t = \frac{\log 2}{\log 1{,}011} = 63{,}4$ jaar

b. $1{,}083^t = 2$

$t = \frac{\log 2}{\log 1{,}083} = 8{,}7$ dus 87 jaar

Opgave 77:

a. $g = 0{,}917$

$0{,}917^t = \frac{1}{2}$

$t = \frac{\log \frac{1}{2}}{\log 0{,}917} = 8$ dagen

b. $0{,}917^t = 0{,}1$

$t = \frac{\log 0{,}1}{\log 0{,}917} = 26{,}6$ dagen

Opgave 78:

a. $2^{\frac{1}{10}} = 1{,}072$ dus 7,2%

b. $g^{25} = 2$

$g = \sqrt[25]{2} = 1{,}028$ dus 2,8%

c. $g^{28} = \frac{1}{2}$

$g = \sqrt[28]{\frac{1}{2}} = 0{,}976$ dus 2,4%

Opgave 79:

0-1500: $g^{1500} = 2$ dus $g = \sqrt[1500]{2} = 1{,}00046$ dus 0,046%

1500-1800: $g^{300} = 2$ dus $g = \sqrt[300]{2} = 1{,}0023$ dus 0,23%

1800-1950: $g^{150} = 2$ dus $g = \sqrt[150]{2} = 1{,}0046$ dus 0,46%

1950-1986: $g^{36} = 2$ dus $g = \sqrt[36]{2} = 1{,}0194$ dus 1,94%

1986-2005: $4{,}8 + 1{,}7 = 6{,}5$ miljard

$g^{19} = \frac{6{,}5}{4{,}8} = 1{,}35$ dus $g = \sqrt[19]{1{,}35} = 1{,}0161$ dus 1,61%

Opgave 80:

$(\frac{1}{2})^t = 0{,}53$

$t = \frac{\log 0{,}53}{\log \frac{1}{2}} = 0{,}916$

$0{,}916 \cdot 5730 = 5248$

$1991 - 5248 = -3257$ dus 3257 voor Christus

Opgave 81:

a. $217 + 2006 = 2223$

$(\frac{1}{2})^{\frac{2223}{5730}} = 0{,}764$ dus 76,4%

b. $(\frac{1}{2})^t = 0{,}77293$

$t = \frac{\log 0{,}77293}{\log \frac{1}{2}} = 0{,}3716$

$0{,}3716 \cdot 5730 = 2129$

$2223 - 2129 = 94$ jaar

Opgave 82:

a. $(\frac{1}{2})^t = 0{,}0002$

$t = \frac{\log 0{,}0002}{\log \frac{1}{2}} = 12{,}29$

$12{,}29 \cdot 8 = 98{,}3$ dagen

b. $g^8 = \frac{1}{2}$

$g = \sqrt[8]{\frac{1}{2}} = 0{,}917$

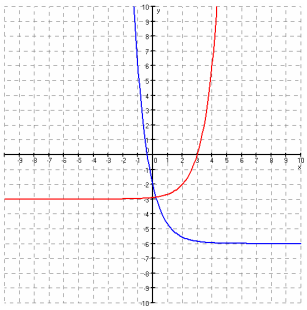
dus 8,3%

5.5 Diagnostische toets hoofdstuk 5

Opgave 1:

a. $f:\ T(2,-3)$

$g:\ V_{x-as,4}\ \ ;\ \ T(0,-6)$

b. 

c. $B_f = \langle -3, \rightarrow \rangle$

$B_g = \langle -6, \rightarrow \rangle$

d. $y_1 = 3^{x-2} - 3$ en $y_2 = 4 \cdot (\frac{1}{3})^x - 6$

de optie intersect geeft $x = 0{,}22$

dus $x \geq 0{,}22$

e. $4 \cdot (\frac{1}{3})^x - 6 \leq 6$

$4 \cdot (\frac{1}{3})^x = 12$

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

$(3^{-1})^x = 3$

$3^{-x} = 3^1$

$-x = 1$

$x \geq -1$

f. $f(4) = 3^2 - 3 = 6$

$-3 < f(x) \leq 6$

Opgave 2:

a. $5^{x-1} = 125 \cdot \sqrt[3]{5}$

$5^{x-1} = 5^3 \cdot 5^{\frac{1}{3}}$

$5^{x-1} = 5^{3\frac{1}{3}}$

$x - 1 = 3\frac{1}{3}$

$x = 4\frac{1}{3}$

b. $3^{2x-5} = \frac{1}{27}\sqrt{3}$

$3^{2x-5} = \frac{1}{3^3} \cdot 3^{\frac{1}{2}}$

$3^{2x-5} = 3^{-3} \cdot 3^{\frac{1}{2}}$

$3^{2x-5} = 3^{-2\frac{1}{2}}$

$2x - 5 = -2\frac{1}{2}$

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

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

c. $2 \cdot 4^{2x-1} - 3 = 61$

$2 \cdot 4^{2x-1} = 64$

$4^{2x-1} = 32$

$(2^2)^{2x-1} = 2^5$

$2^{4x-2} = 2^5$

$4x - 2 = 5$

$4x = 7$

$x = 1\frac{3}{4}$

d. $(\frac{1}{2})^{3x+1} + 6 = 6\frac{1}{8}$

$(\frac{1}{2})^{3x+1} = \frac{1}{8}$

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

$3x + 1 = 3$

$3x = 2$

$x = \frac{2}{3}$

Opgave 3:

a. $9^{x-1} = 27^{x+1}$

$(3^2)^{x-1} = (3^3)^{x+1}$

$3^{2x-2} = 3^{3x+3}$

$2x - 2 = 3x + 3$

$-x = 5$

$x = -5$

b. $2^{x+2} + 2^{x-1} = 36$

$2^2 \cdot 2^x + 2^{-1} \cdot 2^x = 36$

$4 \cdot 2^x + \frac{1}{2} \cdot 2^x = 36$

$4\frac{1}{2} \cdot 2^x = 36$

$2^x = 8$

$2^x = 2^3$

$x = 3$

c. $3^{x+1} = 3^x + 54$

$3 \cdot 3^x - 3^x = 54$

$2 \cdot 3^x = 54$

$3^x = 27$

$3^x = 3^3$

$x = 3$

d. $2^{x^2} = (\frac{1}{8})^x$

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

$2^{x^2} = (2^{-3})^x$

$2^{x^2} = 2^{-3x}$

$x^2 = -3x$

$x^2 + 3x = 0$

$x(x + 3) = 0$

$x = 0 \quad \vee \quad x = -3$

Opgave 4:

a. $H = 20 \cdot 1{,}07^t$

b. $20 \cdot 1{,}07^t = 55$

$1{,}07^t = 2{,}75$

$t = \frac{\log 2{,}75}{\log 1{,}07} = 14{,}95$ dus op 15 mei

c. $y_1 = 20 \cdot 1{,}07^t$

kijk in de tabel, dat is van $t = 19$ naar $t = 20$, dus op 20 mei.

Opgave 5:

a. $g_{dag} = 1{,}1$

$g_{week} = 1{,}1^7 = 1{,}949$ dus met 94,9%

b. $g_{8\,uur} = 1{,}1^{\frac{1}{3}} = 1{,}032$ dus met 3,2%

Opgave 6:

a. $g_{jaar} = 0{,}64$

$g_{maand} = 0{,}64^{\frac{1}{12}} = 0{,}963$ dus met 3,7%

b. $g_{5\ jaar} = 0{,}64^5 = 0{,}107$ dus met 89,3%

Opgave 7:

$g^3 = \frac{1200}{1500} = 0{,}8$

$g = \sqrt[3]{0{,}8} = 0{,}928$

$b = \frac{1500}{0{,}928^4} = 2023$

$N = 2023 \cdot 0{,}928^t$

Opgave 8:

a. ${}^3\log 3\sqrt{3} = {}^3\log 3^{1\frac{1}{2}} = 1\frac{1}{2}$

b. ${}^2\log \frac{1}{16}\sqrt[3]{2} = {}^2\log \frac{1}{2^4} \cdot 2^{\frac{1}{3}} = {}^2\log 2^{-4} \cdot 2^{\frac{1}{3}} = {}^2\log 2^{-3\frac{2}{3}} == -3\frac{2}{3}$

c. ${}^{\frac{1}{3}}\log(\frac{1}{3})^{0{,}6} = 0{,}6$

d. ${}^2\log \frac{1}{4}\sqrt{8} = {}^2\log \frac{1}{2^2} \cdot \sqrt{2^3} = {}^2\log 2^{-2} \cdot 2^{\frac{3}{2}} = {}^2\log 2^{-\frac{1}{2}} = -\frac{1}{2}$

Opgave 9:

a. ${}^4\log(2x - 3) = 2$

$2x - 3 = 4^2$

$2x - 3 = 16$

$2x = 19$

$x = 9\frac{1}{2}$

b. $3 + {}^3\log x = 7$

${}^3\log x = 4$

$x = 3^4 = 81$

c. $^{\frac{1}{2}}\log(x-3) = -4$

$x - 3 = (\frac{1}{2})^{-4}$

$x - 3 = 16$

$x = 19$

d. $5 + 3 \cdot {}^{2}\log x = 20$

$3 \cdot {}^{2}\log x = 15$

$^{2}\log x = 5$

$x = 2^5 = 32$

Opgave 10:

a. $5 \cdot {}^{2}\log 20 = 5 \cdot \frac{\log 20}{\log 2} = 21{,}61$

b. $\frac{6}{{}^{3}\log 30} = \frac{6}{\frac{\log 30}{\log 3}} = 1{,}94$

Opgave 11:

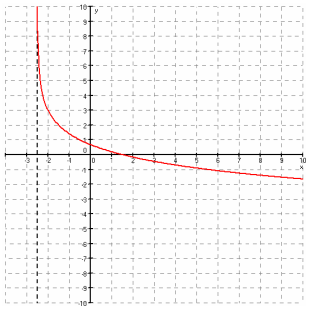
a. $2x + 5 > 0$

$2x > -5$

$x > -2\frac{1}{2}$

$D_f = \langle -2\frac{1}{2}, \rightarrow \rangle$

V.A.: $x = -2\frac{1}{2}$



b. $3 - {}^{2}\log(2x+5) = -2$

$-{}^{2}\log(2x+5) = -5$

$^{2}\log(2x+5) = 5$

$2x + 5 = 2^5$

$2x + 5 = 32$

$2x = 27$

$x = 13\frac{1}{2}$

$-2\frac{1}{2} < x \leq 13\frac{1}{2}$

c. $f(5\frac{1}{2}) = 3 - {}^{2}\log 16 = 3 - 4 = -1$

$f(x) \geq -1$

Opgave 12:

a. f: $x + 1 > 0$

$x > -1$

$D_f = \langle -1, \rightarrow \rangle$

V.A.: $x = -1$

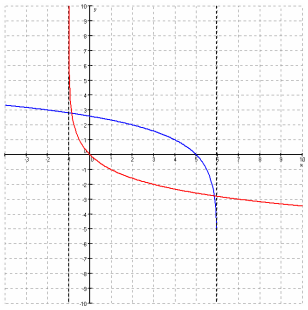
g: $-x + 6 > 0$

$-x > -6$

$x < 6$

$D_g = \langle \leftarrow, 6 \rangle$

V.A.: $x = 6$



b. $^{\frac{1}{2}}\log(x+1) = 4$

$x + 1 = (\frac{1}{2})^4$

$x + 1 = \frac{1}{16}$

$x = -\frac{15}{16}$

c. $g(-2) = {}^{2}\log 8 = 3$

$g(x) \le 3$

d. ${}^{\frac{1}{2}}\log(x+1) = -2$ ${}^{\frac{1}{2}}\log(x+1) = 2$

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

$x+1 = 4$ $x+1 = \frac{1}{4}$

$x = 3$ $x = -\frac{3}{4}$

$-\frac{3}{4} \le x \le 3$

e. $y_1 = \log(x+1)/\log(0.5)$ en $y_2 = \log(-x+6)/\log(2)$

intersect geeft $x = -0{,}85 \quad \vee \quad x = 5{,}85$

$-0{,}85 \le x \le 5{,}85$

f. ${}^{\frac{1}{2}}\log(x+1) = 1$ ${}^{2}\log(-x+6) = 1$

$x+1 = (\frac{1}{2})^{1}$ $-x+6 = 2^{1}$

$x = -\frac{1}{2}$ $-x = -4$

$x = 4$

$AB = 4 - -\frac{1}{2} = 4\frac{1}{2}$

Opgave 13:

$10 \cdot \log \frac{I_1}{10^{-12}} = 78$

$\log \frac{I_1}{10^{-12}} = 7{,}8$ $\log \frac{I_2}{10^{-12}} = 8$ $\log \frac{I_3}{10^{-12}} = 8{,}1$

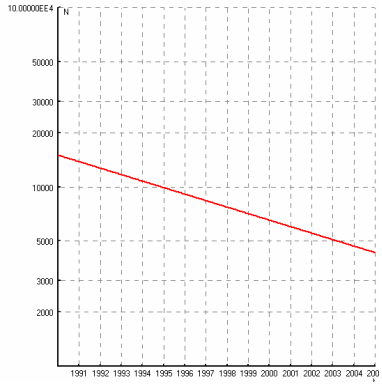
$\frac{I_1}{10^{-12}} = 10^{7{,}8}$ $\frac{I_2}{10^{-12}} = 10^{8}$ $\frac{I_3}{10^{-12}} = 10^{8{,}1}$

$I_1 = 10^{-4{,}2}$ $I_2 = 10^{-4}$ $I_3 = 10^{-3{,}9}$

$I_{tot} = I_1 + I_2 + I_3 = 10^{-4{,}2} + 10^{-4} + 10^{-3{,}9} = 2{,}89 \cdot 10^{-4}$

$L = 10 \cdot \log \frac{2{,}89 \cdot 10^{-4}}{10^{-12}} = 84{,}6$ dB

Opgave 14:

a. 

b. $g^{15} = \frac{4300}{15000} = 0{,}287$

$g = \sqrt[15]{0{,}287} = 0{,}920$

$N = 15000 \cdot 0{,}920^{t}$

Opgave 15:

a. $t = 1 \quad N = 300$

$t = 3 \quad N = 500$

$g^2 = \frac{500}{300} = 1{,}67$

$g = \sqrt{1{,}67} = 1{,}29$

$b = \frac{300}{1{,}29} = 233$

$N = 233 \cdot 1{,}29^t$

b. $t = 1 \quad N = 700$

$t = 3 \quad N = 400$

$g^2 = \frac{400}{700} = 0{,}57$

$g = \sqrt{0{,}57} = 0{,}76$

$b = \frac{700}{0{,}76} = 926$

$N = 926 \cdot 0{,}76^t$

Opgave 16:

a. $g_{maand} = 1{,}002$

$1{,}002^t = 2$

$t = \frac{\log 2}{\log 1{,}002} = 347$ maanden , dus 29 jaar

b. $g_{week} = 0{,}8$

$0{,}8^t = \frac{1}{2}$

$t = \frac{\log \frac{1}{2}}{\log 0{,}8} = 3{,}1$ week , dus 22 dagen

Opgave 17:

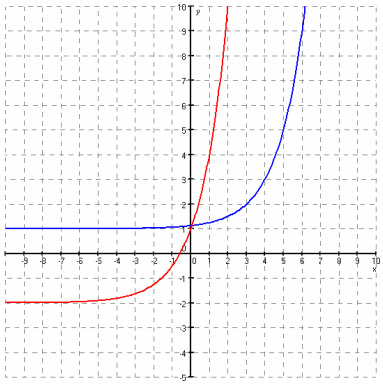
$g^{32} = \frac{1}{2}$

$g = \sqrt[32]{\frac{1}{2}} = 0{,}979$

2,1% afname

Gemengde opgaven hoofdstuk 5 Exponenten en logaritmen

Opgave 1:



a. $y = 2^x \xrightarrow{V_{x-as,3}} y = 3 \cdot 2^x \xrightarrow{T(0,-2)} y = 3 \cdot 2^x - 2$

$y = 2^x \xrightarrow{T(3,1)} y = 2^{x-3} + 1$

b. f: H.A.: $y = -2$ $\quad$ g: H.A.: $y = 1$

$B_f = \langle -2, \rightarrow \rangle$ $\quad$ $B_g = \langle 1, \rightarrow \rangle$

c. $y_1 = 3 \cdot 2^x - 2$ en $y_2 = 2^{x-3} + 1$

intersect geeft $(0{,}06; 1{,}13)$

d. $3 \cdot 2^x - 2 = -\frac{1}{2}$

$3 \cdot 2^x = 1\frac{1}{2}$

$2^x = \frac{1}{2}$

$2^x = 2^{-1}$

$x = -1$

e. $g(7) = 2^4 + 1 = 17$

dus $1 < g(x) \leq 17$

f. $y_1 = 3 \cdot 2^x - 2$ en $y_3 = 9$ intersect geeft $x = 1{,}874$

$y_2 = 2^{x-3} + 1$ en $y_3 = 9$ intersect geeft $x = 6$

dus $AB = 6 - 1{,}873 = 4{,}13$

Opgave 2:

a. $(\frac{1}{2})^{x-5} - 1 = -\frac{3}{4}$

$(\frac{1}{2})^{x-1} = \frac{1}{4}$

$(\frac{1}{2})^{x-5} = (\frac{1}{2})^2$

$x - 5 = 2$

$x = 7$

b. $f(2) = 3 \cdot 2^0 - 3 = 0$

$B_f = \langle -3, \rightarrow \rangle$

dus $-3 < f(x) \leq 0$

c. $f(-1) = -2\frac{5}{8}$

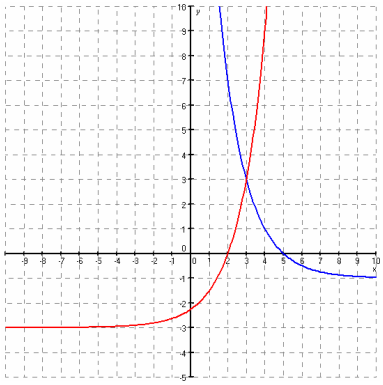
$g(-1) = 63$

$AB = 63 - -2\frac{5}{8} = 65\frac{5}{8}$

d. $y_1 = 3 \cdot 2^{x-2} - 3$ en $y_3 = 4$ intersect geeft $x = 3{,}222$

$y_2 = 0{,}5^{x-5} - 1$ en $y_3 = 4$ intersect geeft $x = 2{,}678$

$PQ = 3{,}222 - 2{,}678 = 0{,}54$



e. $-3 < p \leq -1$

Opgave 3:

a. $30 - 3^{3x+1} = 3$

$-3^{3x+1} = -27$

$3^{3x+1} = 27$

$3^{3x+1} = 3^3$

$3x + 1 = 3$

$3x = 2$

$x = \frac{2}{3}$

b. $5 \cdot 3^{2x} = 15 \cdot \sqrt[4]{3}$

$3^{2x} = 3 \cdot \sqrt[4]{3}$

$3^{2x} = 3^1 \cdot 3^{\frac{1}{4}}$

$3^{2x} = 3^{1\frac{1}{4}}$

$x = \frac{5}{8}$

c. $4 \cdot {}^{3}\log(3x - 5) = 20$

${}^{3}\log(3x - 5) = 5$

$3x - 5 = 3^5$

$3x - 5 = 243$

$3x = 248$

$x = 82\frac{2}{3}$

d. $6 - {}^{0,5}\log 3x = 8$

$-{}^{0,5}\log 3x = 2$

${}^{0,5}\log 3x = -2$

$3x = 0{,}5^{-2}$

$3x = 4$

$x = 1\frac{1}{3}$

e. $2^{x^2-2} = 32$

$2^{x^2-2} = 2^5$

$x^2 - 2 = 5$

$x^2 = 7$

$x = \sqrt{7} \quad \vee \quad x = -\sqrt{7}$

f. $2 + 3 \cdot {}^{\frac{1}{2}}\log(6x + 1) = -4$

$3 \cdot {}^{\frac{1}{2}}\log(6x + 1) = -6$

${}^{\frac{1}{2}}\log(6x + 1) = -2$

$6x + 1 = (\frac{1}{2})^{-2}$

$6x + 1 = 4$

$6x = 3$

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

g. $2 \cdot (\frac{1}{3})^{x-1} + 5 = 59$

$2 \cdot (\frac{1}{3})^{x-1} = 54$

$(\frac{1}{3})^{x-1} = 27$

$(3^{-1})^{x-1} = 3^3$

$3^{-x+1} = 3^3$

$-x+1=3$

$-x=2$

$x=-2$

h. $4^{3x+1} = \frac{1}{8}\sqrt{2}$

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

$2^{6x+2} = 2^{-3}\cdot 2^{\frac{1}{2}}$

$2^{6x+2} = 2^{-2\frac{1}{2}}$

$6x+2 = -2\frac{1}{2}$

$6x = -4\frac{1}{2}$

$x = -\frac{3}{4}$

Opgave 4:

a. $5^{1-3x} = \frac{1}{5}\cdot\sqrt[3]{25}$

$5^{1-3x} = 5^{-1}\cdot\sqrt[3]{5^2}$

$5^{1-3x} = 5^{-1}\cdot 5^{\frac{2}{3}}$

$5^{1-3x} = 5^{-\frac{1}{3}}$

$1-3x = -\frac{1}{3}$

$-3x = -1\frac{1}{3}$

$x = \frac{4}{9}$

b. $4^{3x-x^2} = (\frac{1}{2})^{3-x}$

$(2^2)^{3x-x^2} = (2^{-1})^{3-x}$

$2^{6x-2x^2} = 2^{-3+x}$

$6x-2x^2 = -3+x$

$-2x^2+5x+3=0$

$x = \frac{-5\pm\sqrt{25+24}}{-4} = \frac{-5\pm 7}{-4}$

$x = \frac{-5-7}{-4} = 3 \quad \vee \quad x = \frac{-5+7}{-4} = -\frac{1}{2}$

c. $3^{x-3}+3^{x-4} = \frac{4}{3}\sqrt{3}$

$3^{-3}\cdot 3^x + 3^{-4}\cdot 3^x = \frac{4}{3}\sqrt{3}$

$\frac{1}{27}\cdot 3^x + \frac{1}{81}\cdot 3^x = \frac{4}{3}\sqrt{3}$

$\frac{4}{81}\cdot 3^x = \frac{4}{3}\sqrt{3}$

$3^x = 27\sqrt{3}$

$3^x = 3^3\cdot 3^{\frac{1}{2}}$

$3^x = 3^{3\frac{1}{2}}$

$x = 3\frac{1}{2}$

d. $3-{}^2\log(x-5)=1$

${}^2\log(x-5) = -2$

$^{2}\log(x-5)=2$

$x-5=2^{2}$

$x-5=4$

$x=9$

e. $(\frac{1}{3})^{x+2}=9^{2x-5}$

$(3^{-1})^{x+2}=(3^{2})^{2x-5}$

$3^{-x-2}=3^{4x-10}$

$-x-2=4x-10$

$-5x=-8$

$x=1\frac{3}{5}$

f. $2^{x+2}-2^{x-1}=14\sqrt{2}$

$2^{2}\cdot 2^{x}-2^{-1}\cdot 2^{x}=14\sqrt{2}$

$4\cdot 2^{x}-\frac{1}{2}\cdot 2^{x}=14\sqrt{2}$

$3\frac{1}{2}\cdot 2^{x}=14\sqrt{2}$

$2^{x}=4\sqrt{2}$

$2^{x}=2^{2}\cdot 2^{\frac{1}{2}}$

$2^{x}=2^{2\frac{1}{2}}$

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

g. $(\frac{1}{2})^{-x+2}+2^{x+3}=4\frac{1}{8}$

$(2^{-1})^{-x+2}+2^{x+3}=4\frac{1}{8}$

$2^{x-2}+2^{x+3}=4\frac{1}{8}$

$2^{-2}\cdot 2^{x}+2^{3}\cdot 2^{x}=4\frac{1}{8}$

$\frac{1}{4}\cdot 2^{x}+8\cdot 2^{x}=4\frac{1}{8}$

$8\frac{1}{4}\cdot 2^{x}=4\frac{1}{8}$

$2^{x}=\frac{1}{2}$

$2^{x}=2^{-1}$

$x=-1$

h. $5-3\cdot{}^{\frac{1}{3}}\log x^{2}=-1$

$-3\cdot{}^{\frac{1}{3}}\log x^{2}=-6$

$^{\frac{1}{3}}\log x^{2}=2$

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

$x^{2}=\frac{1}{9}$

$x=\frac{1}{3} \quad \vee \quad x=-\frac{1}{3}$

Opgave 5:

a. $g_{jaar}=1{,}096$

$g^{10}=1{,}096^{10}=2{,}50$ dus een toename van 150%

b. $g_{maand}=1{,}096^{\frac{1}{12}}=1{,}008$ dus een toename van 0,8%

c. $1{,}096^{t}=2$

$t = \frac{\log 2}{\log 1{,}096} = 7{,}56$ jaar , dus 7 jaar en 7 maanden

d. $1{,}096^t = 10$

$t = \frac{\log 10}{\log 1{,}096} = 25{,}1$ dus 25 jaar

Opgave 6:

a. $g_{dag} = 0{,}83$

$g_{week} = 0{,}83^7 = 0{,}271$ dus een afname van 72,9%

b. $g_{uur} = 0{,}83^{\frac{1}{24}} = 0{,}992$ dus een afname van 0,8%

c. $0{,}83^t = 0{,}5$

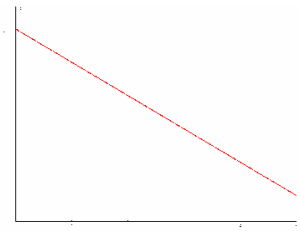
$t = \frac{\log 0{,}5}{\log 0{,}83} = 3{,}72$ dagen , dus 3 dagen en 17 uur

d. $0{,}83^t = 0{,}25$

$t = \frac{\log 0{,}25}{\log 0{,}83} = 7{,}44$ dagen , dus 7 dagen en 11 uur

Opgave 7:

a.



b. $g^{4{,}750} = \frac{567}{1013} = 0{,}56$

$g = 0{,}885$

$P = 1013 \cdot 0{,}885^h$

c. $0{,}885^{0{,}2} = 0{,}976$ dus een afname van 2,4%

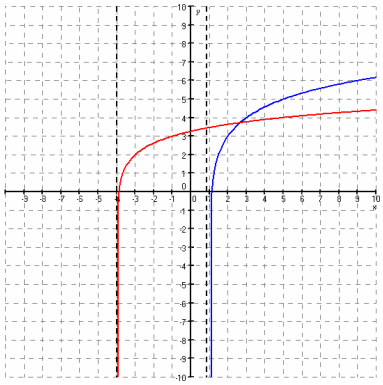
d. $P = 1013 \cdot 0{,}885^{7{,}5} = 405$

Opgave 8:

a. $D_f = \langle -4, \rightarrow \rangle$ $\qquad$ $D_g = \langle 1, \rightarrow \rangle$

V.A.: $x = -4$ $\qquad$ V.A.: $x = 1$

b.



c. $y_1 = 2 + \log(x+4)/\log(3)$ en $y_2 = 3 + \log(x-1)/\log(2)$

intersect geeft $x = 2{,}65$

dus $1 < x \leq 2{,}65$

d. $2+{}^3\log(x+4) \le 5$

$^3\log(x+4) = 3$

$x+4 = 3^3$

$x+4 = 27$

$x = 23$

dus $-4 < x \le 23$

e. $f(6) = 4{,}096$

$g(6) = 5{,}322$

$AB = 5{,}322 - 4{,}096 = 1{,}23$

f.

$2+{}^3\log(x+4) = 2$	$3+{}^2\log(x-1) = 2$
$^3\log(x+4) = 0$	$^2\log(x-1) = -1$
$x+4 = 3^0$	$x-1 = 2^{-1}$
$x+4 = 1$	$x-1 = \frac{1}{2}$
$x = -3$	$x = 1\frac{1}{2}$

$PQ = 1\frac{1}{2} - -3 = 4\frac{1}{2}$

Opgave 9:

a. $N = 1 \cdot 1{,}05^{20} \cdot 0{,}92^{11} = 1{,}06$ miljoen

b. $1{,}05^{20} = 2{,}653$

$2{,}653 \cdot g^{11} = 1$

$g^{11} = 0{,}377$

$g = 0{,}915$ dus een afname van 8,5%

c. $1{,}05^t \cdot 0{,}9^{31-t} = 1$

$y_1 = 1{,}05^x \cdot 0{,}9^{31-x}$ en $y_2 = 1$

intersect geeft $x = 21{,}2$ dus op 22 mei

Opgave 10:

a. $0{,}7^5 = 0{,}168$ dus 16,8%

b. $0{,}7^{10} = 0{,}028$ dus 97,2% wordt geabsorbeerd

c. $0{,}7^d = 0{,}01$

$d = \frac{\log 0{,}01}{\log 0{,}7} = 12{,}9$ dus minstens 13 mm

Opgave 11:

a. $g^7 = 0{,}3$

$g = \sqrt[7]{0{,}3} = 0{,}842$

b. $0{,}842^t = 0{,}6$

$t = \frac{\log 0{,}6}{\log 0{,}842} = 2{,}97$ dagen , dus 71 uur

c. $M = 500 \cdot 0{,}842^t$

$\left[\frac{dM}{dt}\right]_{t=2} = -61\,{}^{mg}\!/_{dag} = -2{,}5\,{}^{mg}\!/_{uur}$

d. $M(7) = 500 \cdot 0{,}842^7 = 150$

$M(10) = 650 \cdot 0{,}842^3 = 388$ mg

e. $M(14) = 650 \cdot 0{,}842^{7} = 195$

$M = 195 \cdot 0{,}842^{t-14}$

Opgave 12:

a. $a \cdot \log 19 = 100$

$a = \frac{100}{\log 19} = 78{,}201$

b. $78 \cdot \log(x+1) = 75$

$\log(x+1) = 0{,}962$

$x + 1 = 10^{0{,}962} = 9{,}2$

$x = 8{,}2$

c. bij de stand $-1{,}3$ hoort $x = \frac{1{,}7}{6} \cdot 18 = 5{,}1$

$P = 78 \cdot \log 6{,}1 = 61$