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[> #Варіант 27
[> restart;
[> # Випадок 1
[>  $d1 := \text{diff}(x(t), t) = r \cdot x(t) \cdot \left(1 - \frac{x(t)}{q}\right) - p$ 

$$d1 := \frac{d}{dt} x(t) = r x(t) \left(1 - \frac{x(t)}{q}\right) - p \quad (1)$$

[>  $r := \frac{27}{4}$ 

$$r := \frac{27}{4} \quad (2)$$

[>  $q := \frac{27}{2}$ 

$$q := \frac{27}{2} \quad (3)$$

[>  $p := \frac{r \cdot q}{4}$ 

$$p := \frac{729}{32} \quad (4)$$

[> #Виллов риби коли квота  $p=729/32$ 
[>  $b, c := \text{evalf}(\text{solve}(\text{rhs}(d1) = 0, x(t)))$ 

$$b, c := 6.750000000, 6.750000000 \quad (5)$$

[> # Вибираємо початкові умови з двох проміжків: (0; 6.75)

$$ma \left(6.75; \frac{27}{2}\right). \text{Наприклад}$$

[>  $a1 := \text{dsolve}(\{d1, x(0) = 5\}, x(t))$ 

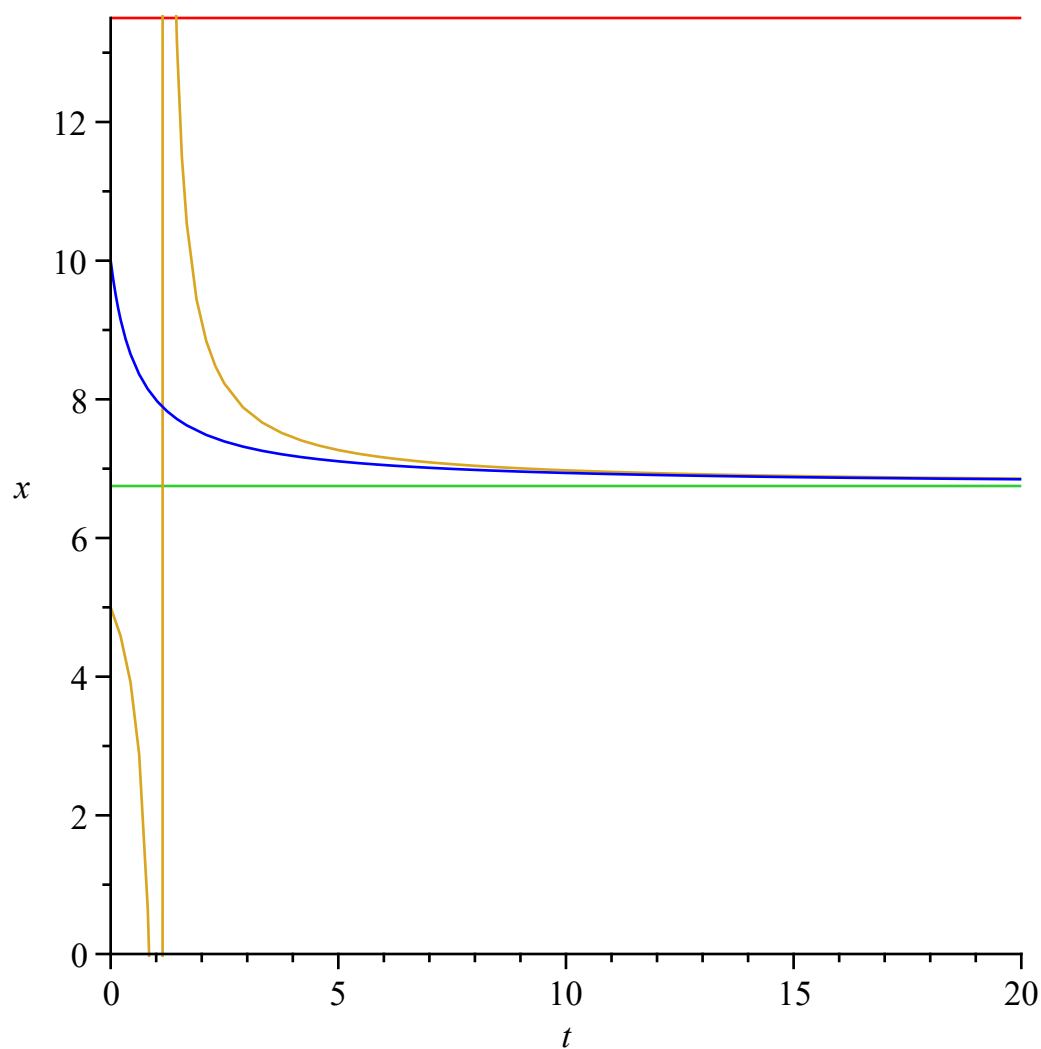
$$a1 := x(t) = \frac{1}{4} \frac{189t - 160}{7t - 8} \quad (6)$$

[>  $a2 := \text{dsolve}(\{d1, x(0) = 10\}, x(t))$ 

$$a2 := x(t) = \frac{1}{4} \frac{351t + 320}{13t + 8} \quad (7)$$

[>
[> with(plots) :
[> plot( {rhs(a1), rhs(a2), b, c, q}, t = 0 .. 20, x = 0 .. q)

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> # *Внадох 2 (квота $p < 729 \setminus 32$)*

> *restart;*

> $d1 := \text{diff}(x(t), t) = r \cdot x(t) \cdot \left(1 - \frac{x(t)}{q}\right) - p$

$$d1 := \frac{d}{dt} x(t) = r x(t) \left(1 - \frac{x(t)}{q}\right) - p \quad (8)$$

> $r := \frac{27}{4}$

$$r := \frac{27}{4} \quad (9)$$

> $q := \frac{27}{2}$

(10)

$$q := \frac{27}{2} \quad (10)$$

$$> p := \frac{r \cdot q}{4} - a \cdot a$$

$$p := \frac{729}{32} - a^2 \quad (11)$$

> # **Виллов риби, коли квота $p < 729/32$**

> #Після віднімання від p параметру a ($a > 0$), параметр керування має бути додатнім

$$> a := 2$$

$$a := 2 \quad (12)$$

$$> evalf(p)$$

$$18.78125000 \quad (13)$$

$$> b, c := evalf(solve(rhs(d1) = 0, x(t)))$$

$$b, c := 3.921572876, 9.578427124 \quad (14)$$

> # Вибираємо початкові умови з трьох проміжків: (0; 3.92), (3.92; 9.578) та $\left(9.578; \frac{27}{2}\right)$. Наприклад

$$> a1 := dsolve(\{d1, x(0) = 2\}, x(t))$$

$$a1 := x(t) = -\frac{1}{8} \left(-27\sqrt{2} + 16 \tanh\left(\frac{1}{2} \left(-2t + \sqrt{2} \operatorname{arctanh}\left(\frac{19}{16}\sqrt{2}\right)\right)\sqrt{2}\right) \right) \sqrt{2} \quad (15)$$

$$> a2 := dsolve(\{d1, x(0) = 6\}, x(t))$$

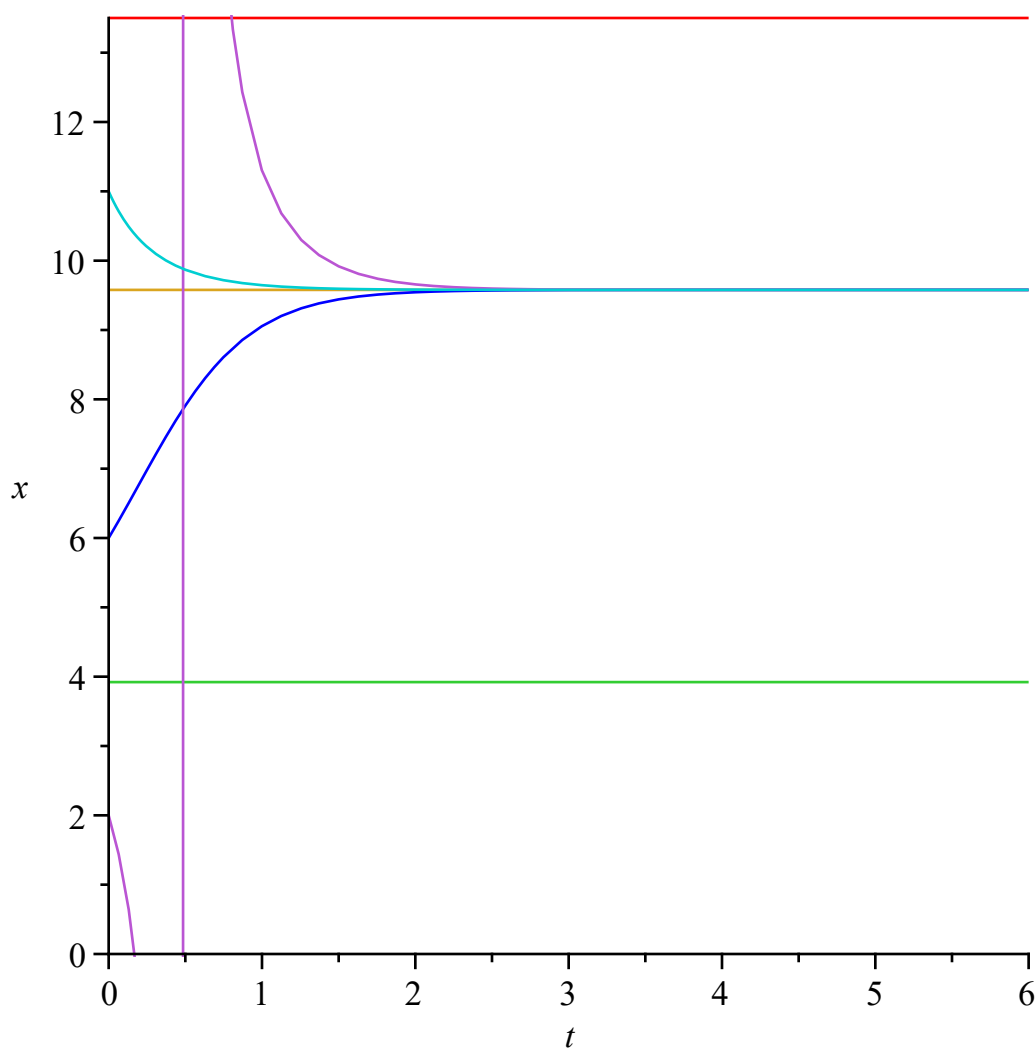
$$a2 := x(t) = -\frac{1}{8} \left(-27\sqrt{2} + 16 \tanh\left(\frac{1}{2} \left(-2t + \sqrt{2} \operatorname{arctanh}\left(\frac{3}{16}\sqrt{2}\right)\right)\sqrt{2}\right) \right) \sqrt{2} \quad (16)$$

$$> a3 := dsolve(\{d1, x(0) = 11\}, x(t))$$

$$a3 := x(t) = \frac{1}{8} \left(27\sqrt{2} + 16 \tanh\left(\frac{1}{2} \left(2t + \sqrt{2} \operatorname{arctanh}\left(\frac{17}{16}\sqrt{2}\right)\right)\sqrt{2}\right) \right) \sqrt{2} \quad (17)$$

> with(plots) :

> plot(\{rhs(a1), rhs(a2), rhs(a3), b, c, q\}, t = 0 .. 6, x = 0 .. q)



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> # **Βυηαδοκ 3 (κβοηα $p > 729 \setminus 32$)**

> *restart*;

> $d1 := \text{diff}(x(t), t) = r \cdot x(t) \cdot \left(1 - \frac{x(t)}{q}\right) - p$

$$d1 := \frac{d}{dt} x(t) = r x(t) \left(1 - \frac{x(t)}{q}\right) - p \quad (18)$$

> $r := \frac{27}{4}$

$$r := \frac{27}{4} \quad (19)$$

> $q := \frac{27}{2}$

(20)

$$q := \frac{27}{2} \quad (20)$$

$$> p := \frac{r \cdot q}{4} + a \cdot a$$

$$p := \frac{729}{32} + a^2 \quad (21)$$

> # *Виллов риби, коли квота p > 729\32*

$$> a := 1$$

$$a := 1 \quad (22)$$

$$> b, c := \text{evalf}(\text{solve}(\text{rhs}(d1) = 0, x(t)))$$

$$b, c := 6.750000000 - 1.414213562 I, 6.750000000 + 1.414213562 I \quad (23)$$

$$> a1 := \text{dsolve}(\{d1, x(0) = 3\}, x(t))$$

$$a1 := x(t) = -\frac{1}{8} \left(-27\sqrt{2} + 8 \tan\left(\frac{1}{2} \left(t + \sqrt{2} \arctan\left(\frac{15}{8}\sqrt{2}\right)\right) \sqrt{2} \right) \right) \sqrt{2} \quad (24)$$

$$> a2 := \text{dsolve}(\{d1, x(0) = 6\}, x(t))$$

$$a2 := x(t) = -\frac{1}{8} \left(-27\sqrt{2} + 8 \tan\left(\frac{1}{2} \left(t + \sqrt{2} \arctan\left(\frac{3}{8}\sqrt{2}\right)\right) \sqrt{2} \right) \right) \sqrt{2} \quad (25)$$

$$> a3 := \text{dsolve}(\{d1, x(0) = 11\}, x(t))$$

$$a3 := x(t) = \frac{1}{8} \left(27\sqrt{2} + 8 \tan\left(\frac{1}{2} \left(-t + \sqrt{2} \arctan\left(\frac{17}{8}\sqrt{2}\right)\right) \sqrt{2} \right) \right) \sqrt{2} \quad (26)$$

> *with(plots) :*

> *plot({rhs(a1), rhs(a2), rhs(a3), q}, t = 0 .. 5, x = 0 .. q)*

