> restart;

> #Вводимо диф-ні рівняння

> $d1 := diff(x(t), t) = x(t) \cdot (e1 - g1 \cdot y(t))$

$$d1 := \frac{d}{dt} x(t) = x(t) \, (3 - y(t)) \tag{1}$$

> $d2 := diff(y(t), t) = y(t) \cdot (-e2 + g2 \cdot x(t))$

$$d2 := \frac{d}{dt} y(t) = y(t) \, (-2 + 4\, x(t)) \tag{2}$$

> # Значення змінних

> $e1 := 3$

$$e1 := 3 \tag{3}$$

> $g1 := 1$

$$g1 := 1 \tag{4}$$

>

> $e2 := 2$

$$e2 := 2 \tag{5}$$

> $g2 := 4$

$$g2 := 4 \tag{6}$$

>

> # Знаходимо стаціонарні точки

> $solve(\{rhs(d1) = 0, rhs(d2) = 0\}, \{x(t), y(t)\})$

$$\{x(t) = 0, y(t) = 0\}, \left\{x(t) = \frac{1}{2}, y(t) = 3\right\} \tag{7}$$

> #Розв'язуємо систему диф-них р-нь чисельними методами при різних початкових умовах

> $dsys1 := dsolve(\{d1, d2, x(0) = 1, y(0) = 5\}, numeric, method = rkf45)$

$$dsys1 := \mathbf{proc}(x\_rkf45) \;\ldots\; \mathbf{end\ proc} \tag{8}$$

> $dsys2 := dsolve(\{d1, d2, x(0) = 5, y(0) = 2\}, numeric, method = rkf45)$

$$dsys2 := \mathbf{proc}(x\_rkf45) \;\ldots\; \mathbf{end\ proc} \tag{9}$$

>

>

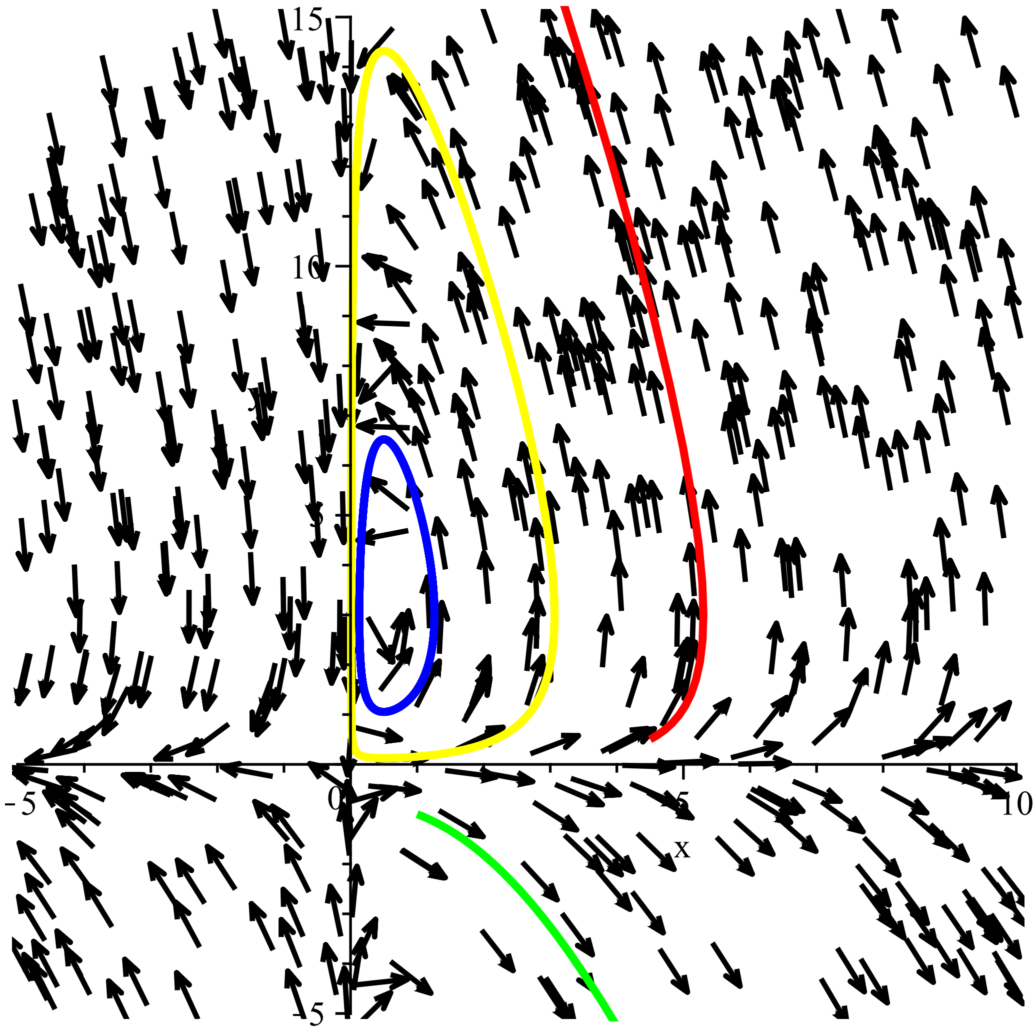
> with(DEtools) :

> with(plots) :

>

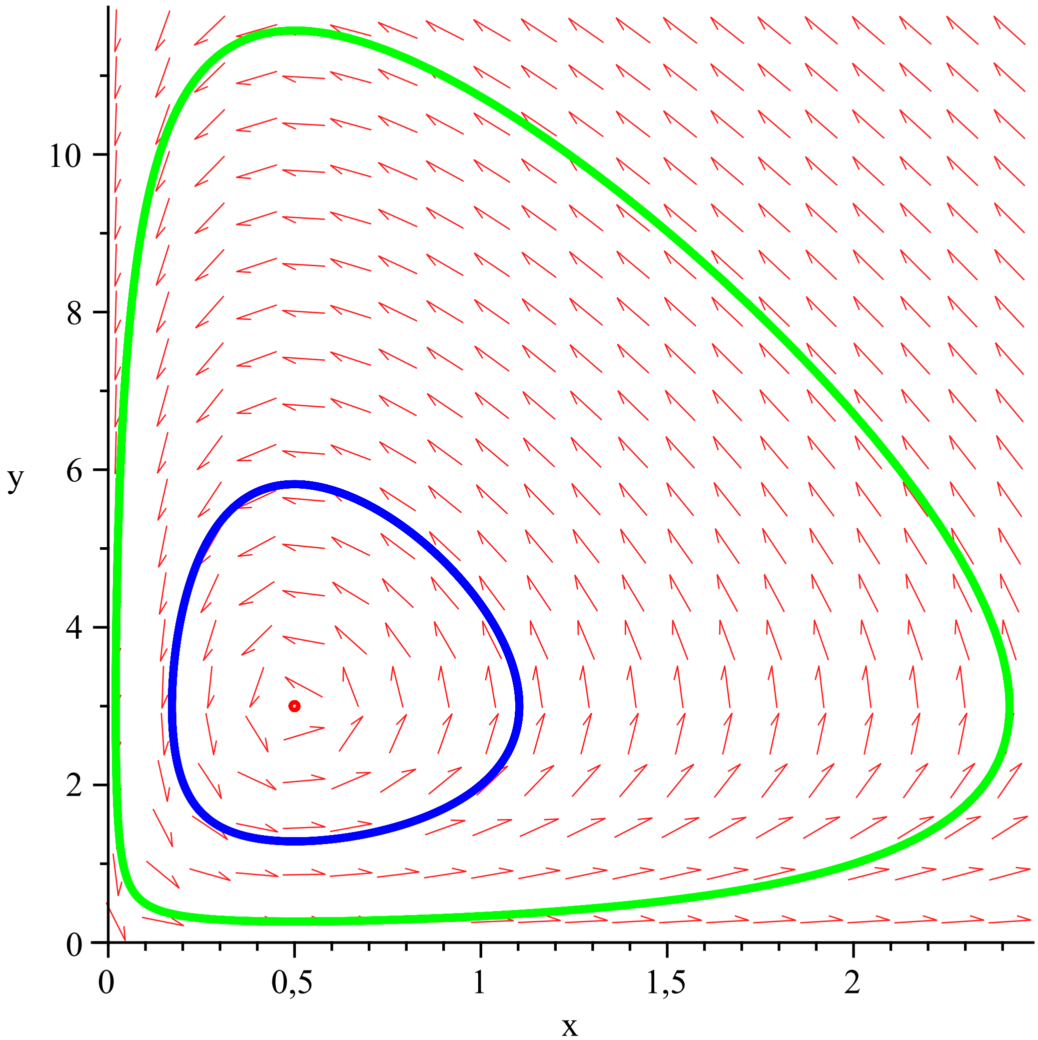
> #Повний фазовий портрет

> $DEplot([d1, d2], [x(t), y(t)], \mathrm{t} = 0 ..10, \mathrm{x} = -5 ..10, \mathrm{y} = -5 ..15, \mathrm{stepsize} = 0.01, [[x(0) = 1, y(0) = 1.5], [x(0) = 3, y(0) = 2], [x(0) = 1, y(0) = -1], [x(0) = 4.5, y(0) = 0.5]], \mathrm{arrows} = \mathrm{smalltwo}, \mathrm{dirfield} = 500, color = black, linecolor = [blue, yellow, green, red])$



> # *Фазовий портрет навколо стаціонарної точки 1\2 та 3* (*для якої ми беремо невеликий приріст* 0.005)

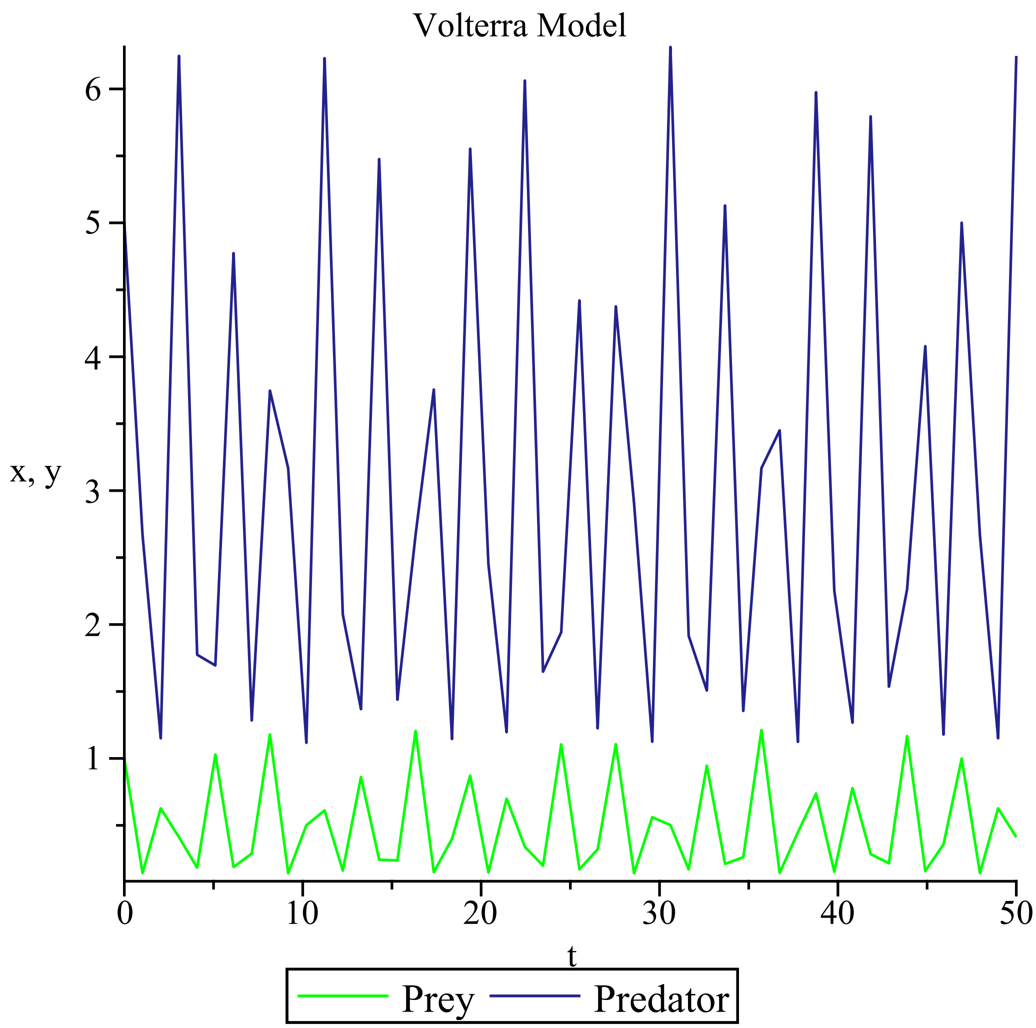
> $phaseportrait\left([d1, d2], [x(t), y(t)], t = 0 .. 10, \left[[x(0) = 1, y(0) = 2], [x(0) = 2, y(0) = 1], \left[x(0) = \frac{1}{2} + 0.005, y(0) = 3 + 0.005\right]\right], stepsize = 0.01, linecolour = [blue, green, red]\right)$



>

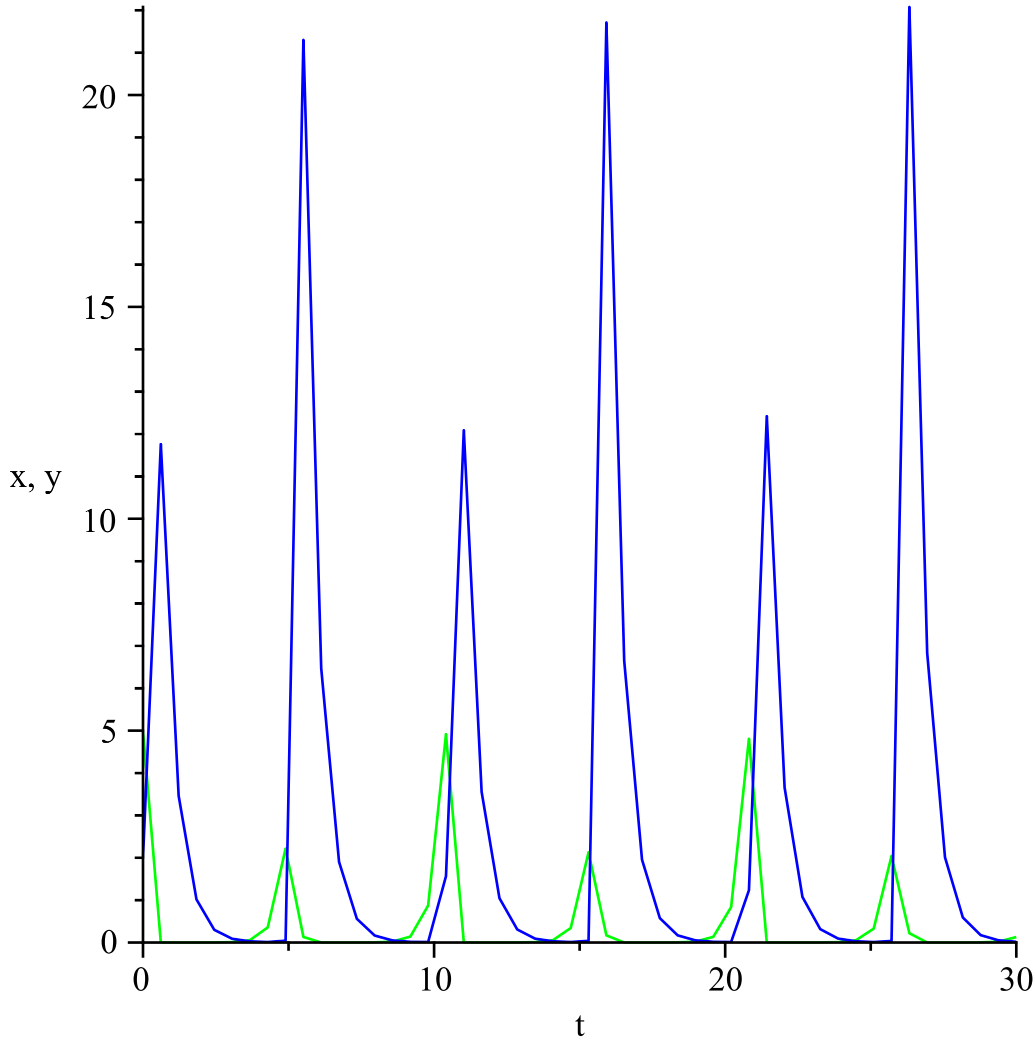
> *#Графік динаміки (при різних початкових умовах)*

> $odeplot(dsys1, [[t, x(t), color = green], [t, y(t), color = navy]], t = 0..50, title = \text{"Volterra Model"}, legend = [\text{"Prey"}, \text{"Predator"}])$

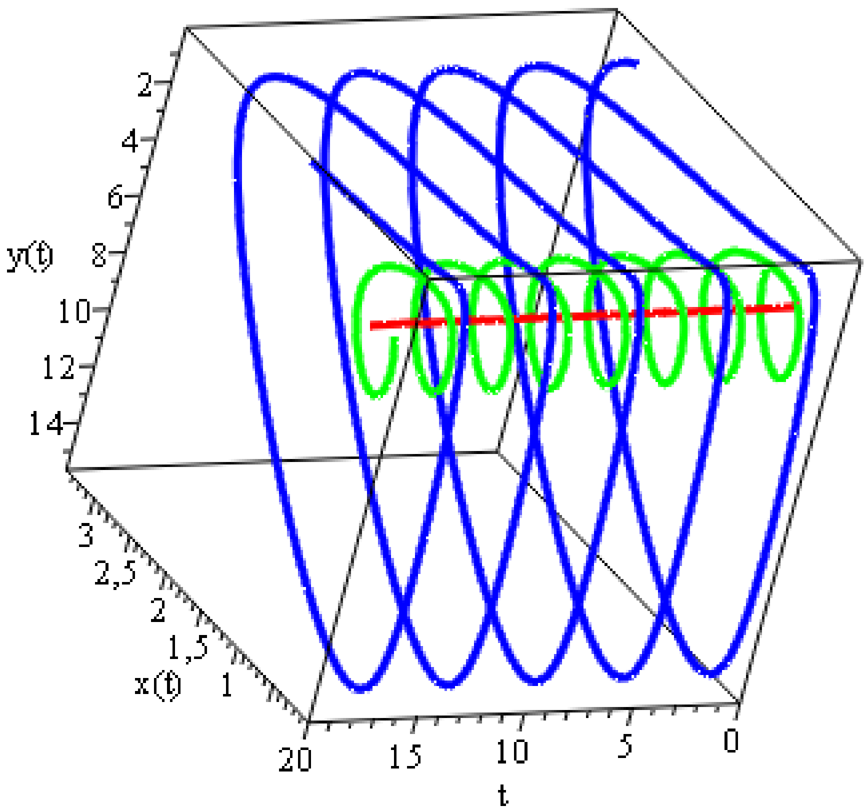


>

> $odeplot(dsys2, [[t, x(t), color = green], [t, y(t), color = blue]], t = 0 ..30)$



> $DEplot3d\left([d1, d2], [x(t), y(t)], t = 0 .. 20, stepsize = 0.01, \left[[x(0) = 3, y(0) = 1], [x(0) = 1, y(0) = 3], \left[x(0) = \frac{1}{2}, y(0) = 3\right]\right], linecolor = [blue, green, red]\right)$



>

> *restart*;

> #Вводимо диф-ні рівняння

> $d1 := diff(x(t), t) = x(t) \cdot (e1 - g1 \cdot y(t) - b1 \cdot x(t))$

$$d1 := \frac{d}{dt} x(t) = x(t) \ (e1 - g1\ y(t) - b1\ x(t)) \tag{10}$$

> $d2 := diff(y(t), t) = y(t) \cdot (-e2 + g2 \cdot x(t))$

$$d2 := \frac{d}{dt} y(t) = y(t) \ (-e2 + g2\ x(t)) \tag{11}$$

> # Значення змінних

> $e1 := 3$

$$e1 := 3 \tag{12}$$

> $g1 := 1$

$$g1 := 1 \tag{13}$$

> $b1 := 1$

(14)

$$b1 := 1 \tag{14}$$

> $e2 := 2$

$$e2 := 2 \tag{15}$$

> $g2 := 4$

$$g2 := 4 \tag{16}$$

> \# Знаходимо стаціонарні точки

> $solve(\{rhs(d1) = 0, rhs(d2) = 0\}, \{x(t), y(t)\})$

$$\{x(t) = 0, y(t) = 0\}, \{x(t) = 3, y(t) = 0\}, \left\{x(t) = \frac{1}{2}, y(t) = \frac{5}{2}\right\} \tag{17}$$

> \#Розв'язуємо систему диф-них р-нь чисельними методами при різних початкових умовах

> $dsys1 := dsolve(\{d1, d2, x(0) = 2, y(0) = 5\}, numeric, method = rkf45)$

$$dsys1 := \mathbf{proc}(x\_rkf45)\ \ldots\ \mathbf{end\ proc} \tag{18}$$

> $dsys2 := dsolve(\{d1, d2, x(0) = 3, y(0) = 1\}, numeric, method = rkf45)$

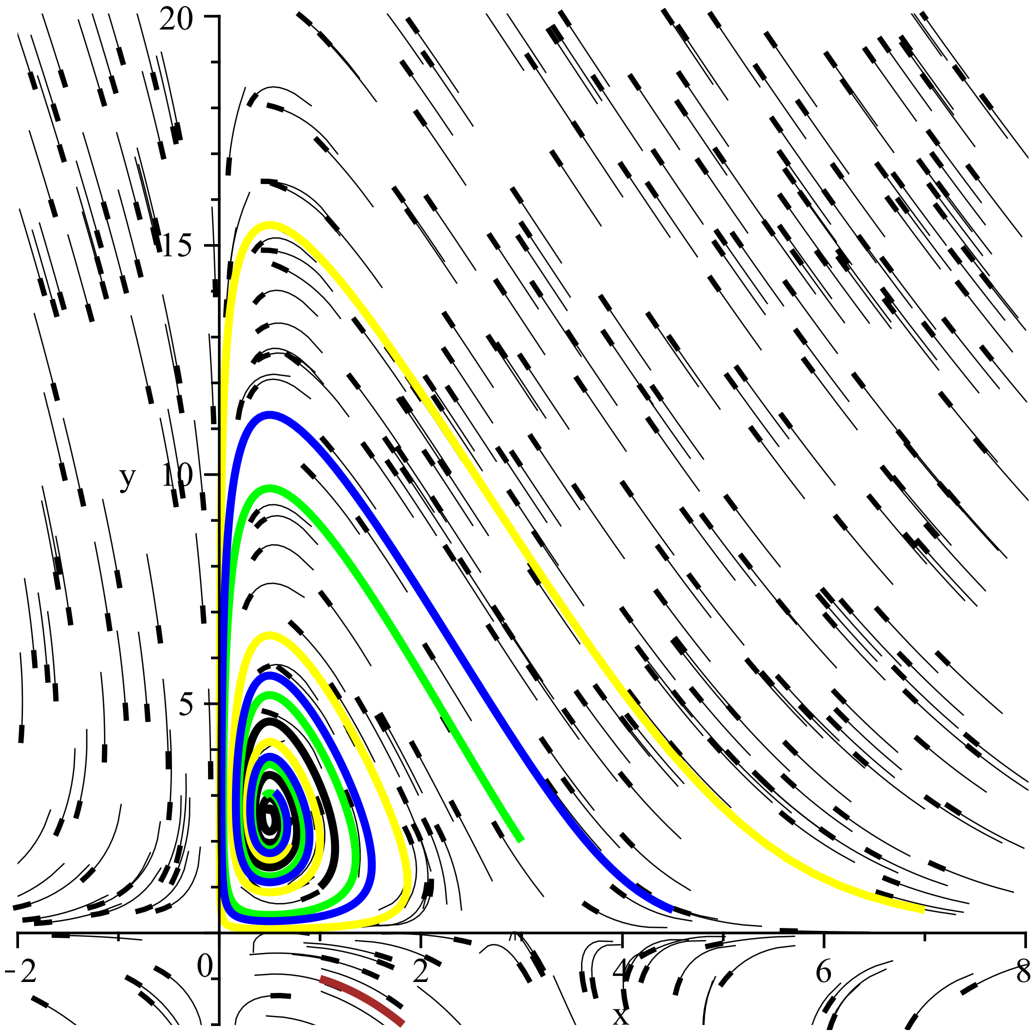
$$dsys2 := \mathbf{proc}(x\_rkf45)\ \ldots\ \mathbf{end\ proc} \tag{19}$$

> $with(DEtools):$

> $with(plots):$

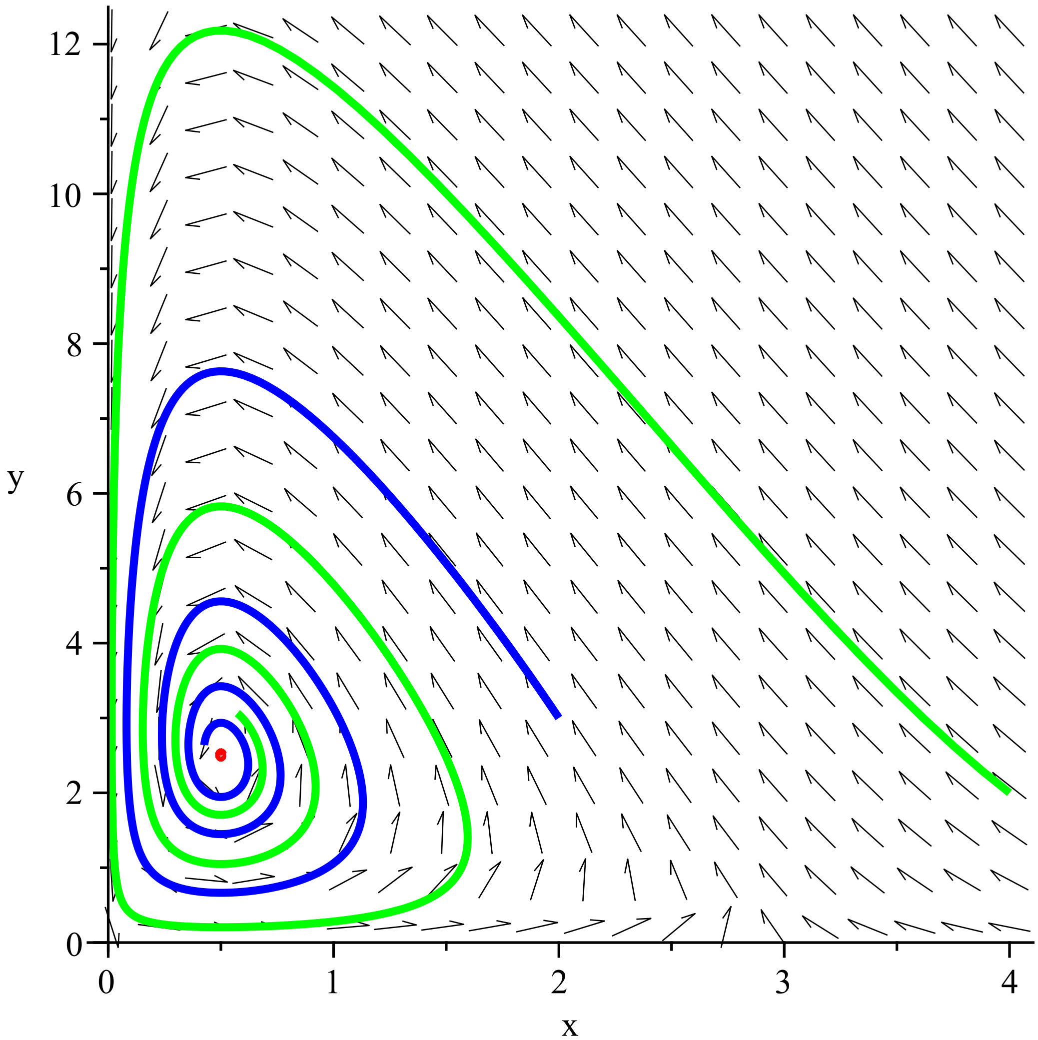
> \#Повний фазовий портрет

> $DEplot([d1, d2], [x(t), y(t)], t = 0..10, x = -2..8, y = -2..20, [[x(0) = 1, y(0) = 1], [x(0) = 3, y(0) = 2], [x(0) = 1, y(0) = -1], [x(0) = 7, y(0) = 0.5], [x(0) = 4.5, y(0) = 0.5]], arrows = curve, color = black, dirfield = 400, linecolor = [black, green, brown, yellow, blue], stepsize = 0.01)$



> #*Фазовий портрет "нетривіальної" стаціонарної точки 3\4 та 17\8*

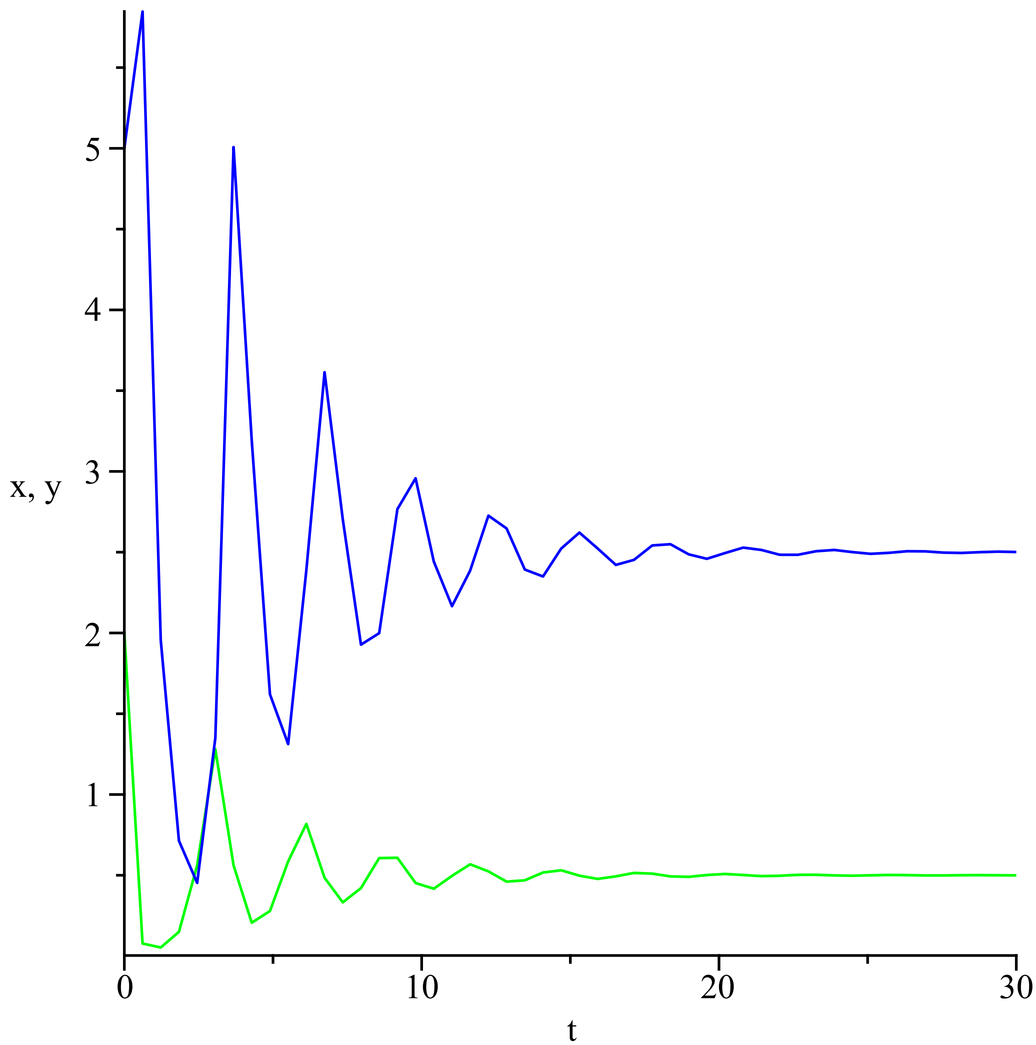
> $phaseportrait\left([d1, d2], [x(t), y(t)], t = 0 .. 10, \left[[x(0) = 2, y(0) = 3], [x(0) = 4, y(0) = 2], \left[x(0) = \frac{1}{2} + 0.01, y(0) = \frac{5}{2} + 0.01\right]\right], stepsize = 0.01, linecolour = [blue, green, red], color = black\right)$



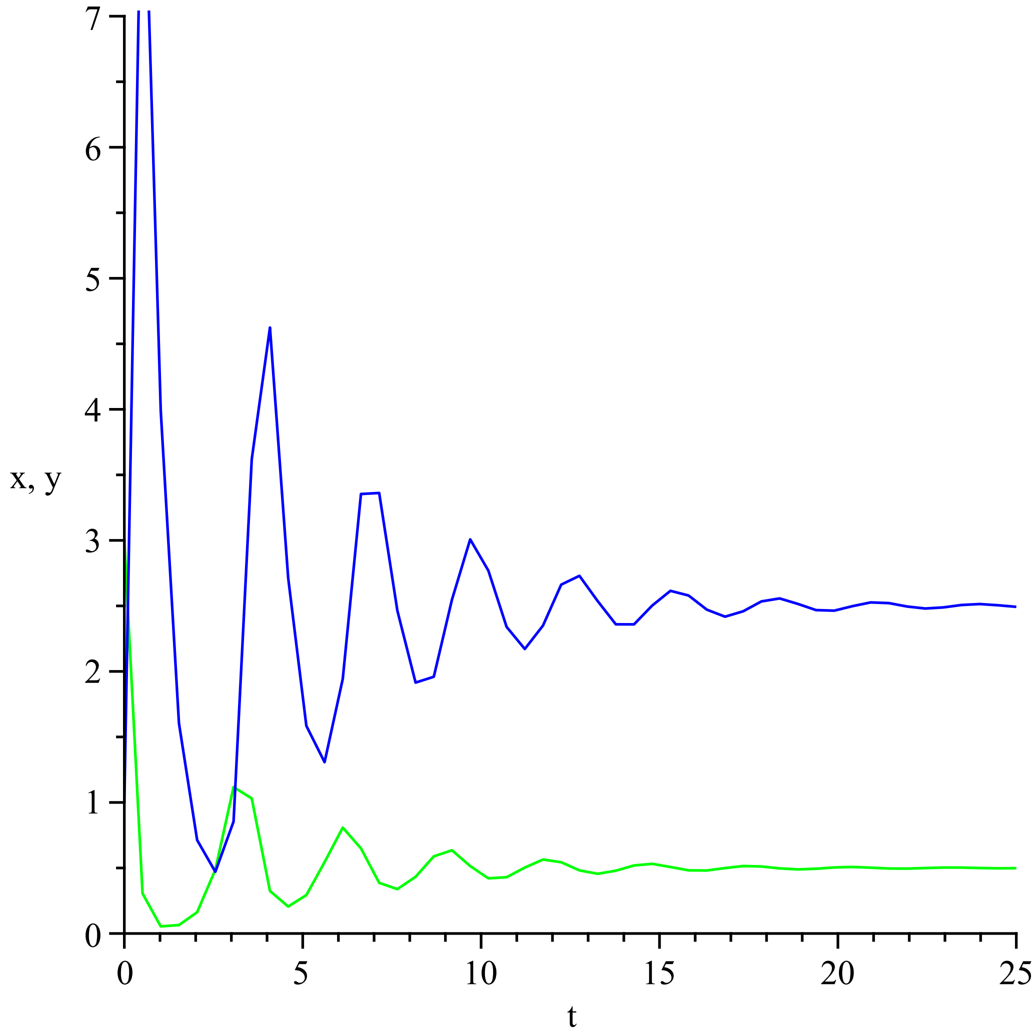
>

> *#Графік динаміки (при різних початкових умовах)*

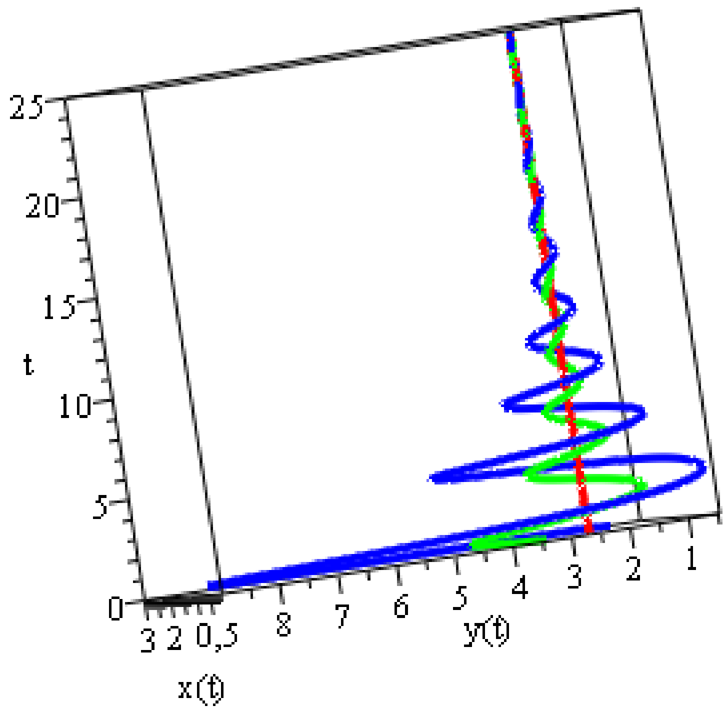
> $odeplot(dsys1, [[t, x(t), color = green], [t, y(t), color = blue]], t = 0..30)$



$> \ odeplot(dsys2, [[t, x(t), color = green], [t, y(t), color = blue]], t = 0 \,..25, view = [0 \,..25, 0 \,..7])$



$> DEplot3d\left(\{d1, d2\}, \{x(t), y(t)\}, t = 0 .. 25, stepsize = 0.01, \left[[x(0) = 3, y(0) = 1], [x(0) = 1, y(0) = 3], \left[x(0) = \frac{1}{2}, y(0) = \frac{5}{2}\right]\right], linecolor = [blue, green, red]\right)$




```
> 
> restart;
> 
```