```
> Maple permet aussi de générer des tableaux de
> valeurs numériques obtenues par la méthode ici gear (voir M5)
> de1 := {(D@@2)(x)(t)=-y(t),
> (D@@2)(y)(t)=D(x)(t)+y(t)}:
> init1 := {x(0)=1, D(x)(0)=0, y(0)=0, D(y)(0)=1}:
> F := dsolve(de1 union init1, {x(t),y(t)},type=numeric, method=mgear,
> value=array([0,.6,1.1,1.5,2.3,2.5]));
```

$$F := \left[\begin{array}{c} \left[t,\ \mathrm{x}(t),\ \frac{\partial}{\partial t}\,\mathrm{x}(t),\ \mathrm{y}(t),\ \frac{\partial}{\partial t}\,\mathrm{y}(t)\right] \\ \left[\begin{array}{ccccc} 0 & 1. & 0 & 0 & 1. \\ .6 & .9634119549 & -.1848064217 & .6311283580 & 1.148218373 \\ 1.1 & .7669145867 & -.6543597977 & 1.269965676 & 1.421274383 \\ 1.5 & .3877481908 & -1.282704182 & 1.888433444 & 1.670452370 \\ 2.3 & -1.394576262 & -3.372722646 & 3.379308882 & 1.978146378 \\ 2.5 & -2.139341124 & -4.088057357 & 3.773066380 & 1.948716231 \end{array}\right] \end{array} \right]$$

```
> nops(F);
```

$$1$$

```
> A:=F[2,1];
```

$$A := F_{2,\,1}$$

```
> evalm(A);
```

$$\left[\begin{array}{ccccc} 0 & 1. & 0 & 0 & 1. \\ .6 & .9634119549 & -.1848064217 & .6311283580 & 1.148218373 \\ 1.1 & .7669145867 & -.6543597977 & 1.269965676 & 1.421274383 \\ 1.5 & .3877481908 & -1.282704182 & 1.888433444 & 1.670452370 \\ 2.3 & -1.394576262 & -3.372722646 & 3.379308882 & 1.978146378 \\ 2.5 & -2.139341124 & -4.088057357 & 3.773066380 & 1.948716231 \end{array}\right]$$

```
> #ou directement.A utiliser lorsque l'on veut
> présenter des tests d'une méthode
> seq(F[2,1][i,2],i=1..6);
```

$$1.,\ .9634119549,\ .7669145867,\ .3877481908,\ -1.394576262,\ -2.139341124$$

```
> #On peut aussi utiliser l'option
> listprocedure pour avoir x(t) comme fonction de t de facon plus rapide
> que dans l'exemple du fichier
> ff :=
> dsolve({diff(x(t),t)=y(t),diff(y(t),t)=x(t)+y(t),x(0)=2,y(0)=1},
> {x(t),y(t)}, type=numeric, output=listprocedure);
> fx := subs(ff,x(t)): fy := subs(ff,y(t)):
> fx(0), fy(0);
```

$$ff := [t = (\mathbf{proc}(t)\ \ldots\ \mathbf{end}),\ \mathrm{x}(t) = (\mathbf{proc}(t)\ \ldots\ \mathbf{end}),\ \mathrm{y}(t) = (\mathbf{proc}(t)\ \ldots\ \mathbf{end})]$$

$$2.,\ 1.$$

```
> fx(12);
```

$$.2706691493977095\,10^{9}$$

```
> restart :Gamma(1);nops(Gamma);
```

$$\Gamma(1)$$

$$1$$

```
> nops(eval(GAMMA));
```

$$6$$

```
> op(4,eval(GAMMA));# pas étonnant que Maple
> ait des problemes pour simplifier .......
```

$$\mathrm{table}([\ \frac{1}{2} = \sqrt{\pi}\ ])$$

```
> myGAMMA := proc(x)
> option remember;
> if x=0 then 1
> elif is(x,integer) then  x*myGAMMA(x-1) else GAMMA(x) fi;
> end:
> myGAMMA(0);myGAMMA(2);
```

$$1$$

$$2$$

```
> nops(myGAMMA);
```

$$1$$

```
> nops(eval(myGAMMA));
```

$$6$$

```
> op(4,eval(myGAMMA));
```

$$\mathrm{table}([\ 2 = 2,\ 1 = 1,\ 0 = 1\ ])$$

```
> myGAMMA(n):=factorial(n-1);
```

$$2$$

$$\mathrm{myGAMMA}(n) := (n-1)!$$

```
> op(4,eval(myGAMMA));
```

$$\begin{array}{l}\mathrm{table}([\\ \quad 2 = 2\\ \quad n = (n-1)!\\ \quad 1 = 1\\ \quad 0 = 1\\ \quad])\end{array}$$

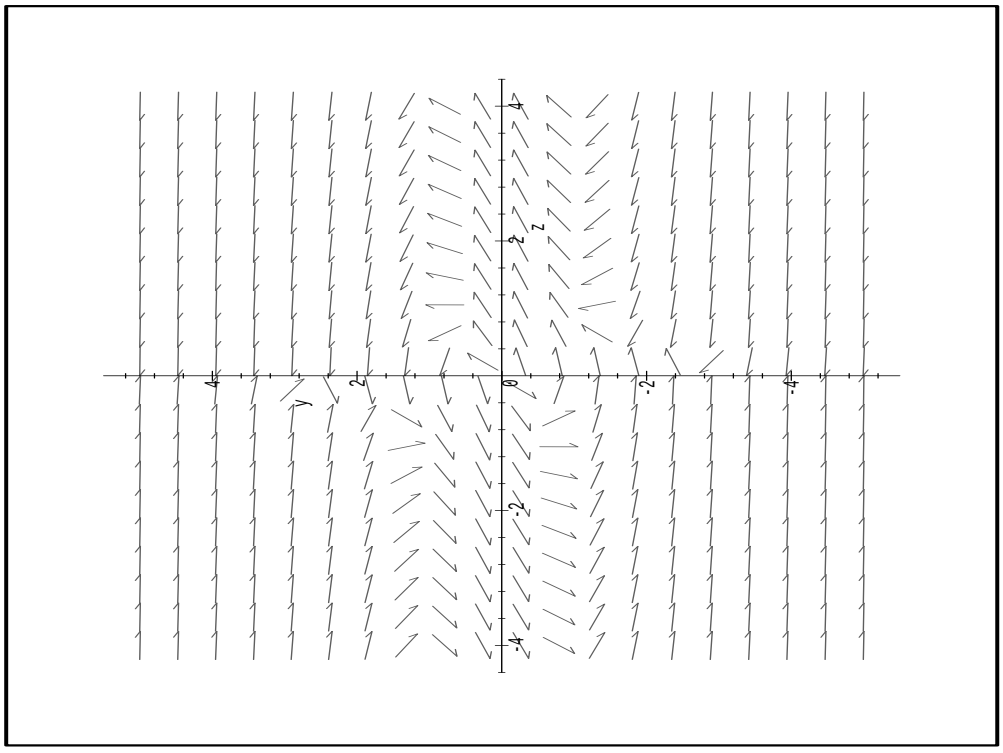
```
> # on y est arrivé .....
> # Van der Pol
> VDP:=
> diff(y(x),x,x)+((y(x))^2-2)*diff(y(x),x) +y(x) = 0;
```

$$VDP := (\frac{\partial^2}{\partial x^2}\,\mathrm{y}(x)) + (\mathrm{y}(x)^2 - 2)\,(\frac{\partial}{\partial x}\,\mathrm{y}(x)) + \mathrm{y}(x) = 0$$

```
> VDPsyst:={diff(y(x),x)=z(x), diff(z(x),x)=
> (2-(y(x))^2)*z(x) -y(x)};
```

$$VDPsyst := \{\frac{\partial}{\partial x}\,\mathrm{y}(x) = \mathrm{z}(x),\ \frac{\partial}{\partial x}\,\mathrm{z}(x) = (2 - \mathrm{y}(x)^2)\,\mathrm{z}(x) - \mathrm{y}(x)\}$$

```
> with(DEtools):
> DEplot(VDPsyst,{z(x),y(x)},x=-5..5,y=-5..5,z=-4..4,stepsize=.05);
```



```
> CI:=[[y(0)=1,z(0)=-2],[y(0)=3.14,z(0)=0],[y(0
> )=0,z(0)=0.44]];
```

$$CI := [[y(0) = 1, z(0) = -2], [y(0) = 3.14, z(0) = 0], [y(0) = 0, z(0) = .44]]$$

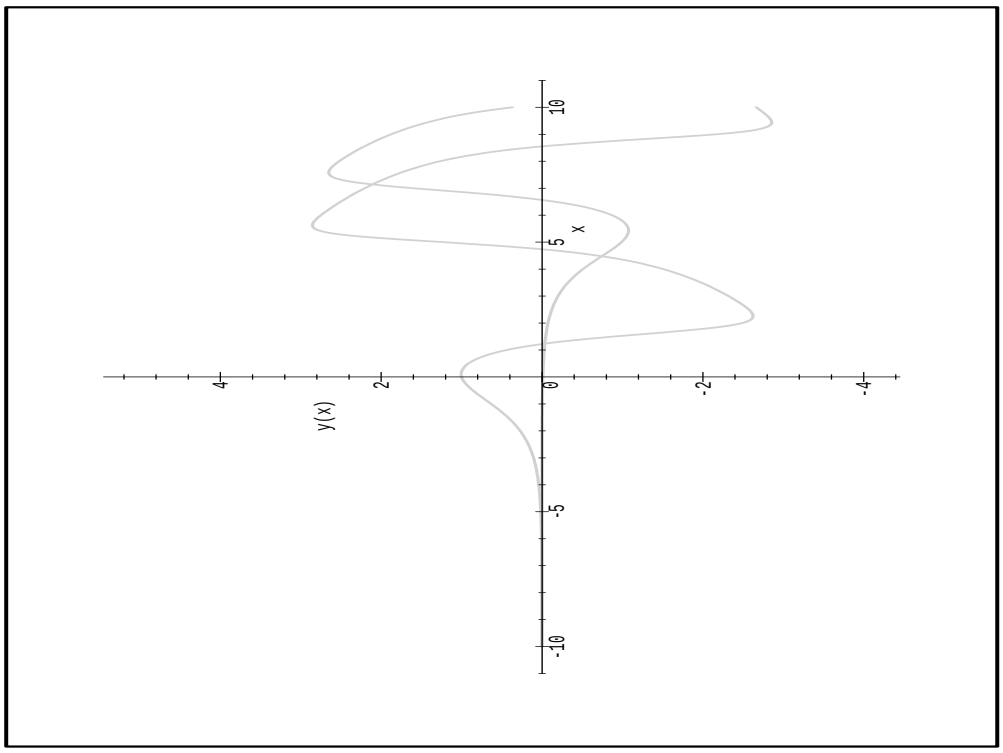
```
> CDINIT:=[seq([y(0)=0.01* k,D(y)(0)=0.2*k], k=
> 1..10)];
```

$$CDINIT := [[y(0) = .01, D(y)(0) = .2], [y(0) = .02, D(y)(0) = .4], [y(0) = .03, D(y)(0) = .6], [y(0) = .04, D(y)(0) = .8], [y(0) = .05, D(y)(0) = 1.0], [y(0) = .06, D(y)(0) = 1.2], [y(0) = .07, D(y)(0) = 1.4], [y(0) = .08, D(y)(0) = 1.6], [y(0) = .09, D(y)(0) = 1.8], [y(0) = .10, D(y)(0) = 2.0]]$$

```
> CONDINIT:=[[y(0)=-0.01,D(y)(0)=-0.01],[y(0)=1
> ,D(y)(0)=0.1]];
```

$$CONDINIT := [[y(0) = -.01, D(y)(0) = -.01], [y(0) = 1, D(y)(0) = .1]]$$

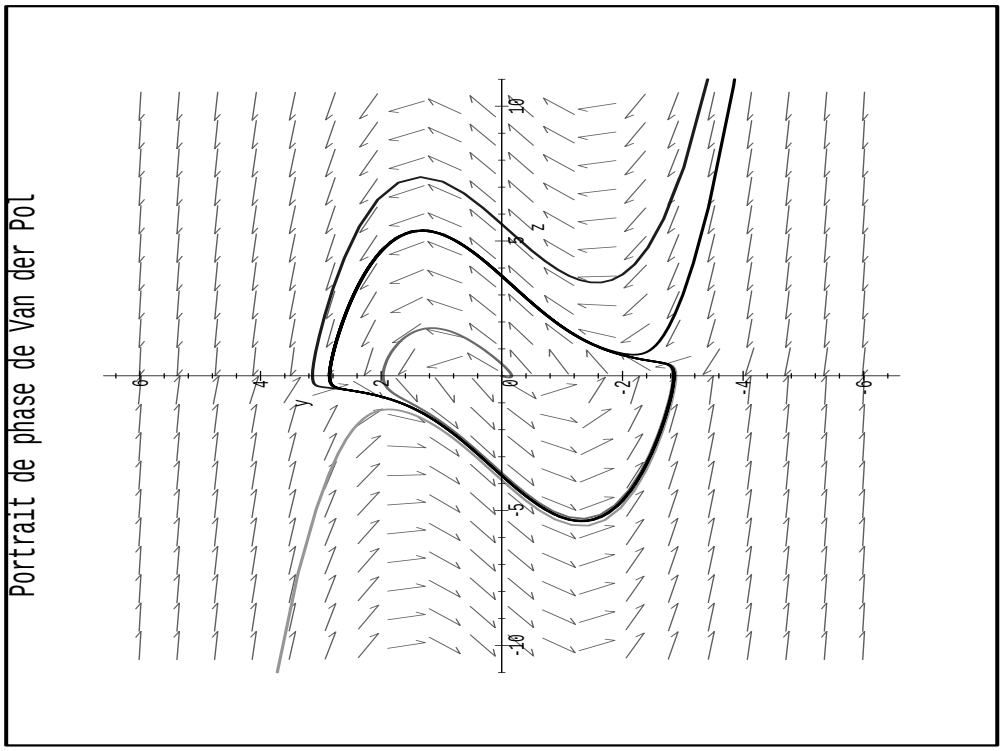
```
> DEplot({VDP},\
> {y(x)},x=-10..10,CONDINIT,y=-4..5,stepsize=.05);
```




```
> CDINIT:=[[y(0)=1,z(0)=-2],[y(0)=3.14,z(0)=0],
> [y(0)=0,z(0)=0.44],[y(0)=-3,z(0)=3]];
```

$$CDINIT := [[y(0) = 1, z(0) = -2], [y(0) = 3.14, z(0) = 0], [y(0) = 0, z(0) = .44], [y(0) = -3, z(0) = 3]]$$

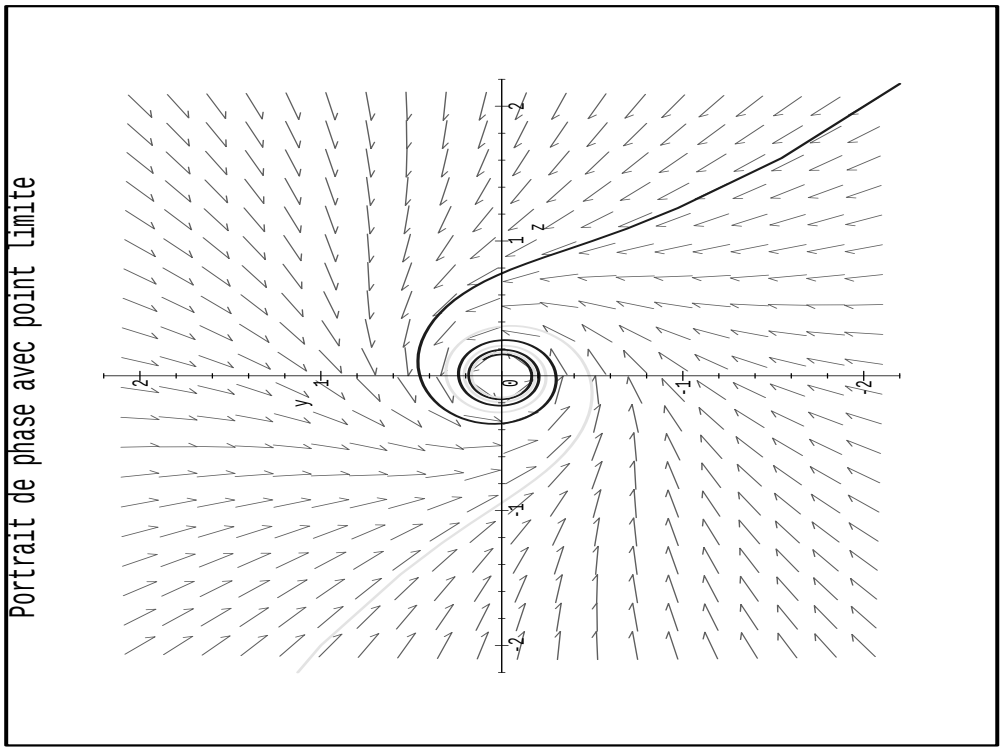
```
> DEplot(VDPsyst,{y(x),z(x)},x=-40..20,y=-6..
> 6,z=-10..10,CDINIT,linecolor=[blue,magenta,green,black],title=‘Portrai
> t de phase de Van der Pol‘,stepsize=0.05);
> # faire varier "x" pour voir apparaitre le
> phénomène
```




```
> restart: with(DEtools):cerclelimite :=
> {diff(y(x),x)=z(x)-(y(x)^2+ z(x)^2) * y, diff(z(x),x)=- (y(x)^2+
> z(x)^2) *z(x) -y(x)};
> CDINIT:=[[y(0)=1,z(0)=-2],[y(0)=3.14,z(0)=0],[y(0)=0.01,z(0)=0.44],[y(
> 0)=-3,z(0)=3]];
> DEplot(cerclelimite,{y(x),z(x)},x=-20..20,y=-2..2,z=-2..2,[[y(0)=1,z
> (0)=-2],[y(0)=-0.5,z(0)=1]],linecolor=[blue,yellow],title=‘Portrait de
> phase avec point limite‘,stepsize=0.1);
```

$$cerclelimite := \{\frac{\partial}{\partial x}\,\mathrm{z}(x) = -(\mathrm{y}(x)^2 + \mathrm{z}(x)^2)\,\mathrm{z}(x) - \mathrm{y}(x),\ \frac{\partial}{\partial x}\,\mathrm{y}(x) = \mathrm{z}(x) - (\mathrm{y}(x)^2 + \mathrm{z}(x)^2)\,y\}$$

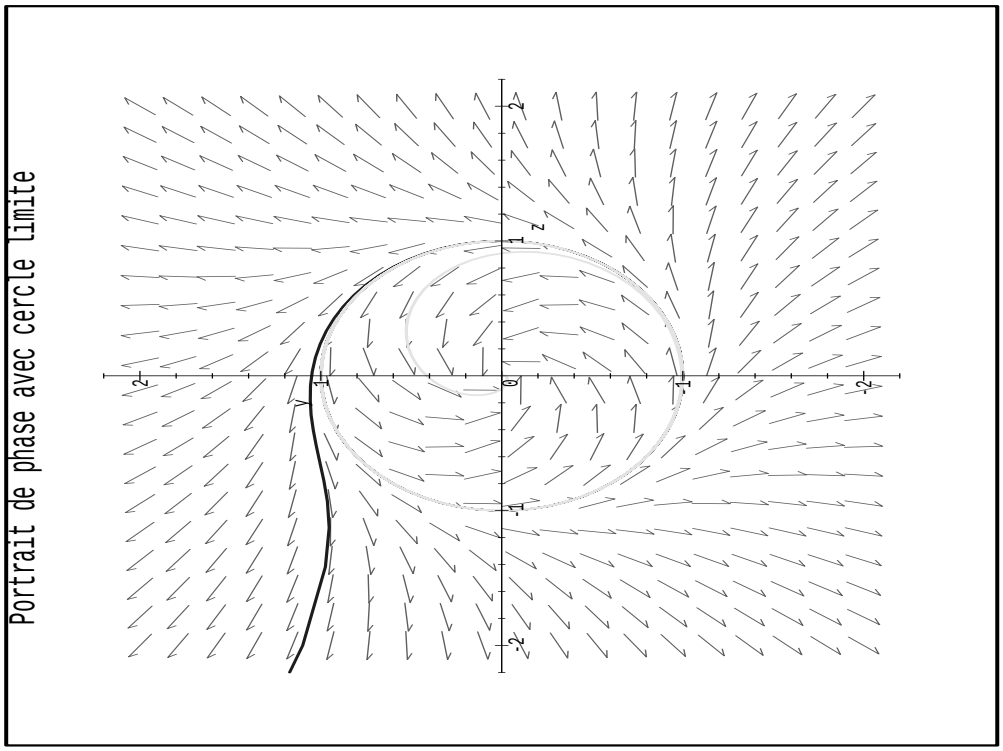
$$CDINIT := [[\mathrm{y}(0) = 1,\ \mathrm{z}(0) = -2],\ [\mathrm{y}(0) = 3.14,\ \mathrm{z}(0) = 0],\ [\mathrm{y}(0) = .01,\ \mathrm{z}(0) = .44],\ [\mathrm{y}(0) = -3,\ \mathrm{z}(0) = 3]]$$




```
> restart: with(DEtools):cerclelimite :=
> {diff(y(x),x)=z(x)-(1-y(x)^2- z(x)^2) * y, diff(z(x),x)=-
> (1-y(x)^2-z(x)^2) *z(x) -y(x)};
> CDINIT:=[[y(0)=1,z(0)=-2],[y(0)=3.14,z(0)=0],[y(0)=0.01,z(0)=0.44],[y(
> 0)=-3,z(0)=3]];
> DEplot(cerclelimite,{y(x),z(x)},x=-20..30,y=-2..2,z=-2..2,[[y(0)=1.1
> ,z(0)=-2],[y(0)=0.5,z(0)=0.5]],linecolor=[blue,yellow],title=‘Portrait
> de phase avec cercle limite‘,stepsize=0.1);
```

$$cerclelimite := \{\frac{\partial}{\partial x}\,\mathrm{z}(x) = -(1-\mathrm{y}(x)^2-\mathrm{z}(x)^2)\,\mathrm{z}(x) - \mathrm{y}(x),\ \frac{\partial}{\partial x}\,\mathrm{y}(x) = \mathrm{z}(x) - (1-\mathrm{y}(x)^2-\mathrm{z}(x)^2)\,y\}$$

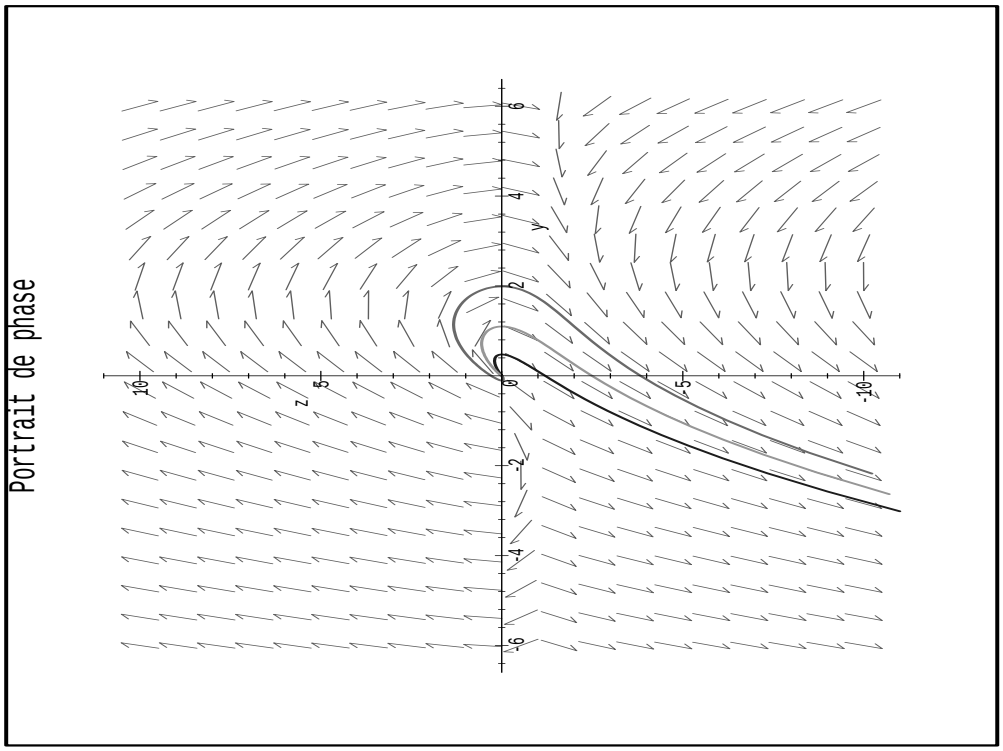
$$CDINIT := [[\mathrm{y}(0)=1,\ \mathrm{z}(0)=-2],\ [\mathrm{y}(0)=3.14,\ \mathrm{z}(0)=0],\ [\mathrm{y}(0)=.01,\ \mathrm{z}(0)=.44],\ [\mathrm{y}(0)=-3,\ \mathrm{z}(0)=3]]$$




```
> # question : comment faire pour voir si le
> cercle est répulsif ou attractif ....
> restart:
> with(DEtools):VDPMsyst:={diff(y(x),x)=z(x), diff(z(x),x)=
> (2-(y(x)))*z(x) -y(x)};
```

$$VDPMsyst := \{\frac{\partial}{\partial x}\,\mathrm{y}(x) = \mathrm{z}(x),\ \frac{\partial}{\partial x}\,\mathrm{z}(x) = (2 - \mathrm{y}(x))\,\mathrm{z}(x) - \mathrm{y}(x)\}$$

```
> DEplot(VDPMsyst,{y(x),z(x)},x=-10..20,y=-6.
> .6,z=-10..10,[[y(0)=0.1,z(0)=-1.],[y(0)=1.1,z(0)=-2],[y(0)=0.5,z(0)=0.
> 5]],linecolor=[blue,magenta,green],title=‘Portrait de phase
> ‘,stepsize=0.05);
```


Portrait de phase
z
y
10
5
0
-5
-10
6
4
2
-2
-4
-6