```
>   # chaos example; sfb 22 mar 01
>   sigma:=10;r:=28;b:=8/3;
```

$$\sigma := 10$$
$$r := 28$$
$$b := \frac{8}{3}$$

```
>   Lorenz:=[diff(x(t),t)=-sigma*x(t)+sigma*y(t),
>   diff(y(t),t)=r*x(t)-y(t)-x(t)*z(t),
>   diff(z(t),t)=-b*z(t)+x(t)*y(t)];
```

Lorenz := $[\frac{\partial}{\partial t}\,\mathrm{x}(t) = -10\,\mathrm{x}(t) + 10\,\mathrm{y}(t),\ \frac{\partial}{\partial t}\,\mathrm{y}(t) = 28\,\mathrm{x}(t) - \mathrm{y}(t) - \mathrm{x}(t)\,\mathrm{z}(t),$

$\frac{\partial}{\partial t}\,\mathrm{z}(t) = -\frac{8}{3}\,\mathrm{z}(t) + \mathrm{x}(t)\,\mathrm{y}(t)]$

```
>   with(DEtools);
```

[*DEnormal*, *DEplot*, *DEplot3d*, *DEplot_polygon*, *DFactor*, *DFactorLCLM*, *DFactorsols*,
Dchangevar, *GCRD*, *LCLM*, *PDEchangecoords*, *RiemannPsols*, *Xchange*,
Xcommutator, *Xgauge*, *abelsol*, *adjoint*, *autonomous*, *bernoullisol*, *buildsol*,
buildsym, *canoni*, *caseplot*, *casesplit*, *checkrank*, *chinisol*, *clairautsol*,
constcoeffsols, *convertAlg*, *convertsys*, *dalembertsol*, *dcoeffs*, *de2diffop*, *dfieldplot*,
diffop2de, *dsubs*, *eigenring*, *endomorphism_charpoly*, *equinv*, *eta_k*, *eulersols*,
exactsol, *expsols*, *exterior_power*, *firint*, *firtest*, *formal_sol*, *gen_exp*, *generate_ic*,
genhomosol, *gensys*, *hamilton_eqs*, *indicialeq*, *infgen*, *initialdata*, *integrate_sols*,
intfactor, *invariants*, *kovacicsols*, *leftdivision*, *liesol*, *line_int*, *linearsol*, *matrixDE*,
matrix_riccati, *moser_reduce*, *muchange*, *mult*, *mutest*, *newton_polygon*,
normalG2, *odeadvisor*, *odepde*, *parametricsol*, *phaseportrait*, *poincare*, *polysols*,
ratsols, *redode*, *reduceOrder*, *reduce_order*, *regular_parts*, *regularsp*,
remove_RootOf, *riccati_system*, *riccatisol*, *rifsimp*, *rightdivision*, *rtaylor*,
separablesol, *solve_group*, *super_reduce*, *symgen*, *symmetric_power*,
symmetric_product, *symtest*, *transinv*, *translate*, *untranslate*, *varparam*, *zoom*]

```
>   p1:=DEplot(Lorenz, [x(t),y(t),z(t)], t=0..50,
>{[x(0)=5,y(0)=10,z(0)=10]}, scene=[t,x], stepsize=0.01,
>   linecolor=red, thickness=0, axes=box):
>   p1;
```
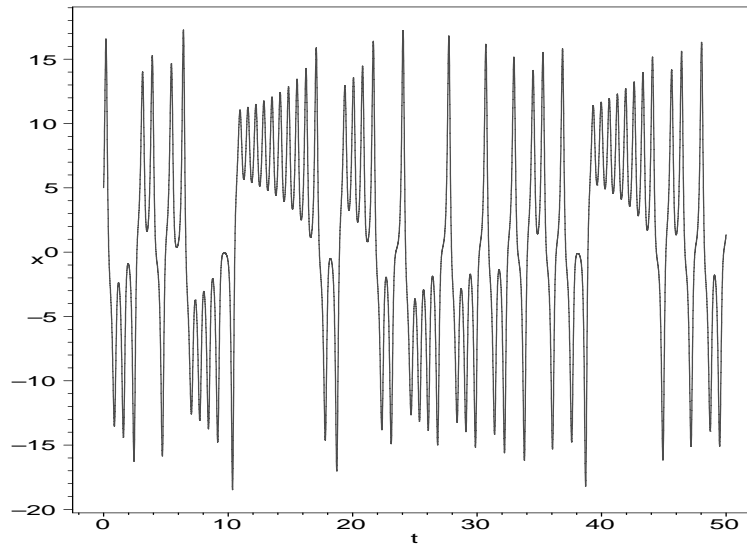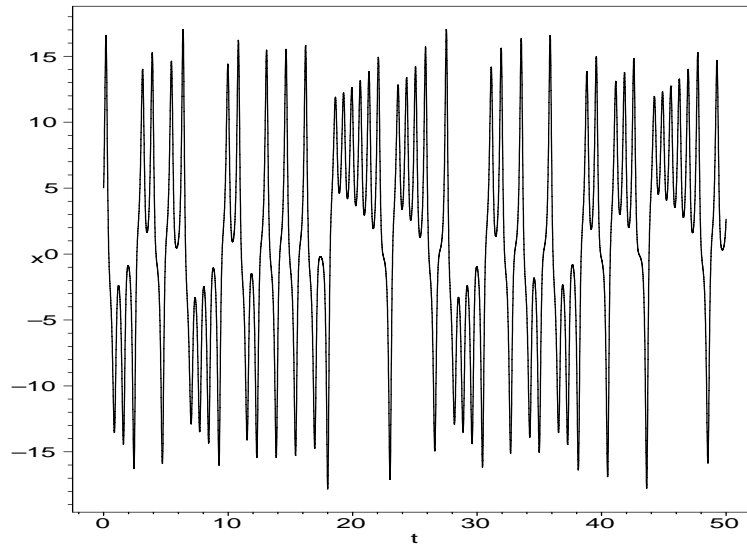
```
>   p2:=DEplot(Lorenz, [x(t),y(t),z(t)], t=0..50,
>{[x(0)=5.01,y(0)=10,z(0)=10]}, scene=[t,x], stepsize=0.01,
>   linecolor=black, thickness=0, axes=box):

>   p2;
```



```
>   with(plots);
```

Warning, the name changecoords has been redefined

[animate, animate3d, animatecurve, changecoords, complexplot, complexplot3d, conformal, contourplot, contourplot3d, coordplot, coordplot3d, cylinderplot, densityplot, display, display3d, fieldplot, fieldplot3d, gradplot, gradplot3d, implicitplot, implicitplot3d, inequal, listcontplot, listcontplot3d, listdensityplot, listplot, listplot3d, loglogplot, logplot, matrixplot, odeplot, pareto, pointplot, pointplot3d, polarplot, polygonplot, polygonplot3d, polyhedra_supported, polyhedraplot, replot, rootlocus, semilogplot, setoptions, setoptions3d, spacecurve, sparsematrixplot, sphereplot, surfdata, textplot, textplot3d, tubeplot]

```
>  #The only difference is the 0.01 difference in the initial value
for
>  x(0), 5 vs 5.01, but note how eventually the curves are totally
>  different
```

```
>  display(p1,p2,title="sensitive dependence on initial conditions");
```


sensitive dependence on initial conditions
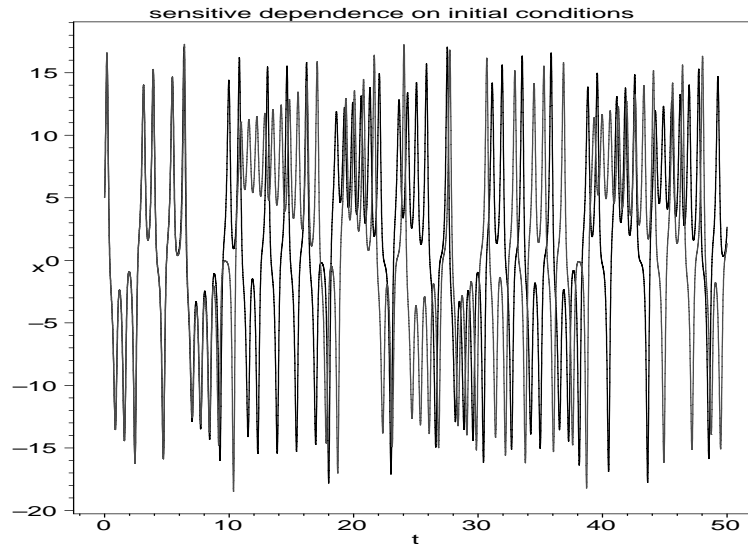
```
>  p3:=DEplot(Lorenz, [x(t),y(t),z(t)], t=0..50,
>{[x(0)=5,y(0)=10,z(0)=10]}, scene=[x,z], stepsize=0.01,
>  linecolor=red, thickness=0, axes=box, title="The Lorenz Strange
>  Attractor"):p3;
```

The Lorenz Strange Attractor