diff

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*** desolve(de, dvar, ics=None, ivar=None, show_method=False, contrib_ode=False)

*** desolve_laplace(de, dvar, ics=None, ivar=None)

R6.<a0, a1, a2, a3, a4, a5, a6> = PolynomialRing(QQ,7)

R.<x> = PowerSeriesRing(R6)

*** from sage.calculus.desolvers import desolve_rk4

desolve_rk4(de, dvar, ics, ivar=None, end_points=None, step=0.1, output='list',or 'plot' or 'slop_field')

*** from sage.calculus.desolvers import desolve_rk4_determine_bounds

desolve_rk4_determine_bounds(ics, end_points=None)

*** from sage.calculus.desolvers import eulers_ method

x,y = PolynomialRing(QQ,2,"xy").gens()

eulers_method(f, x0, yo, h, x1, algorithm='table')#'None'

*** desolve_system(des, vars, ics=None, ivar=None)

*** from sage.calculus.desolvers import desolve_system_rk4

desolve_system_rk4(des, vars, ics=None, ivar=None, end_points=None,step=0.1)

*** from sage.calculus.desolvers import eulers_method_2x2

t, x, y = PolynomialRing(QQ, 3, "txy").gens()

eulers_method_2x2(f, g, t0, x0, yo, h, t1, algorithm='table')

*** RR = RealField(sci_not = 0, prec = 4, rnd = 'RNDU')

t,x,y = PolynomialRing (RR, 3, "t x y").gens()
de1 = diff(y,x) + y - 1 == 0
de2 = diff(y,x,2) - y == x
de3 = diff(y,x,2) + y == 0
de4 = diff(y,x)^2 + x*diff(y,x) - y == 0
de5 = x^2*diff(y,x) == a + b*x^n + c*x^2*y^2
de6 = diff(y,x) - exp(-x) - y == 0
de7 = diff(y,x,3) - diff(y,x,2) == 12*x^2 + 6*x
de8 = diff(y,x,3) + 2*diff(y,x,2) - 5*diff(y,x) - 6*y == 0
de10 = x^2*diff(y,x,2) + x*diff(y,x) + x^2*y == 0
de11 = x^2*diff(y,x,2) + x*diff(y,x) + (x^2-9)*y == 0
de12 = diff(y,x) == x*y*(2-y)
de13 = diff(y,x) == y*(2-y)
de14 = diff(y,x) == y*(y-1) + 2-x
de15 = diff(y,x) == 5*x + y -5
de16 = diff(y,x) == sin(x) + y
de17 = diff(y,x) == y + sin(pi/3 *x)
des1 = [diff(x,t) == 1-y, diff(y,t) == x-1]
des2 = [diff(x,t) -x*(1-y) == 0,diff(y,t)+y*(1-x) == 0]
des3 = [diff(x,t) == 4*x-2*y+2*t, diff(y,t) == 8*x-4*y+1]

```
x=var('x')
y=function('y',x)
de1=diff(y,x)+y-1==0
show(de1)
desolve(de1,y)
```

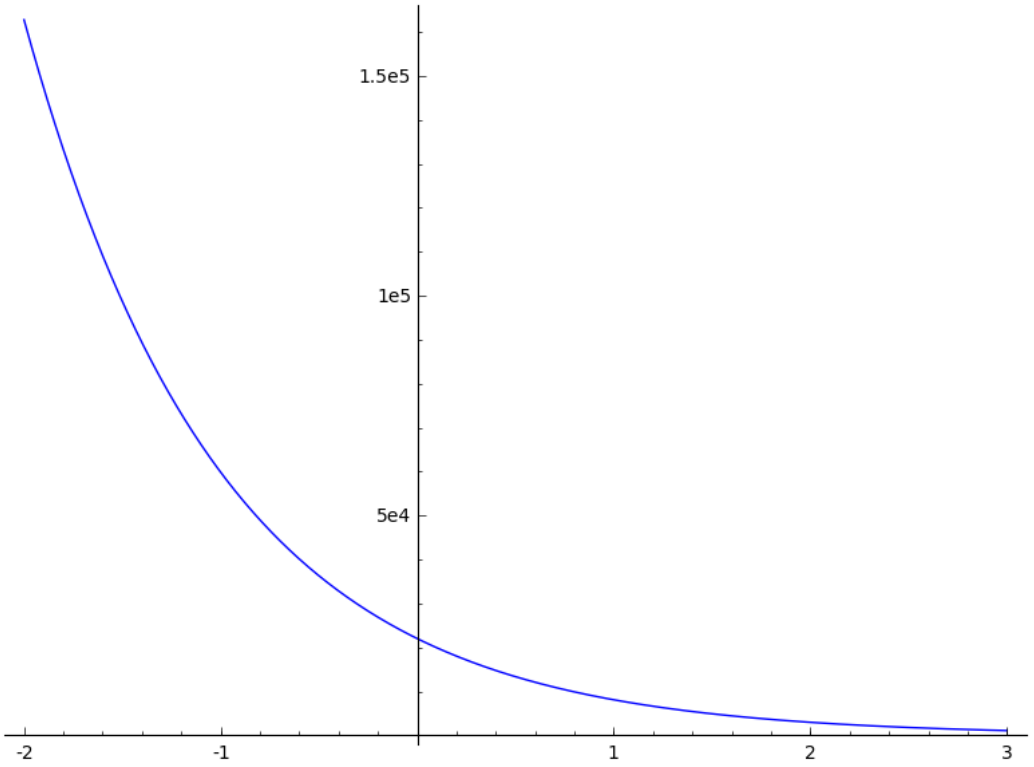
$$y\left(x\right) + D[0]\left(y\right)\left(x\right) - 1 = 0$$

```
(_C + e^x)*e^(-x)
```

```
desolve(de1,y,ics=[10,2])
```

```
(e^10 + e^x)*e^(-x)
```

```
x=var('x')
y=function('y',x)
de1 = diff(y,x) + y - 1 == 0
plot(desolve(de1,y,ics=[10,2]),x,-2,3)
```




```
de2 = diff(y,x,2) - y == x
de2.show()
desolve(de2,y,[10,2,1])
```

$$-y\left(x\right)+D[0,0]\left(y\right)\left(x\right)=x$$

```
-x + 7*e^(x - 10) + 5*e^(-x + 10)
```

```
de3 = diff(y,x,2) + y == 0
show(de3)
```

$$y\left(x\right)+D[0,0]\left(y\right)\left(x\right)=0$$

```
desolve(de3,y,ics=[0,1,pi/2,4])
```

```
cos(x) + 4*sin(x)
```

```
de4 = diff(y,x)^2 + x*diff(y,x) - y == 0
desolve(de4,y, contrib_ode = True,show_method=true)
```

```
[[y(x) == _C^2 + _C*x, y(x) == -1/4*x^2], 'clairault']
```

```
a,b,c,n=var('a b c n')
de5 = x^2*diff(y,x) == a + b*x^n + c*x^2*y^2
desolve(de5,y,ivar=x, contrib_ode =True,show_method=true)
```

```
[[[y(x) == 0, (b*x^(n - 2) + a/x^2)*c^2*u == 0]], 'riccati']
```

```
assume(n>1)
show(desolve_laplace(de5, y,  ivar=x))
```

$$\mathcal{L}^{-1}\left(\left(cg_{4371}^{n+1}D[2,2]\mathcal{L}\left(y(x)^{2},x,g_{4371}\right)+ag_{4371}^{n}+b\Gamma\left(n+1\right)-2\,g_{4371}^{n+1}D[2]\mathcal{L}\left(y\left(x\right),x,g_{4371}\right)\right)g_{4371}^{-n-2},g_{4371},x\right)$$

```
x=var('x')
y=function('y',x)
de3=diff(y,x,2)+y==0
desolve(de3, y, ics=[0,1,pi/2,4])
```

```
cos(x) + 4*sin(x)
```

```
y=function('y',x)
de6 = diff(y,x) - exp(-x) - y == 0
desolve_laplace(de6,y,ics=[0,3])
```

```
-1/2*e^(-x) + 7/2*e^x
```

```
de7 = diff(y,x,3) - diff(y,x,2) == 12*x^2 + 6*x
desolve_laplace(de7,y)
```

```
-x^4 - 5*x^3 - 15*x^2 + 1/2*x*(D[0](y)(0) - D[0, 0](y)(0) - 30) + (D[0,
0](y)(0) + 30)*e^x + 1/2*x*D[0](y)(0) - 1/2*x*D[0, 0](y)(0) - 15*x +
y(0) - D[0, 0](y)(0) - 30
```

```
desolve(de7,y, contrib_ode =True)
```

```
Traceback (click to the left of this block for traceback)
...
NotImplementedError: Maxima was unable to solve this ODE.
```

```
de10 = x^2*diff(y,x,2) + x*diff(y,x) + x^2*y == 0
de10.show()
```

$$x^{2} y\left(x\right) + x^{2} D[0, 0]\left(y\right)\left(x\right) + x D[0]\left(y\right)\left(x\right) = 0$$

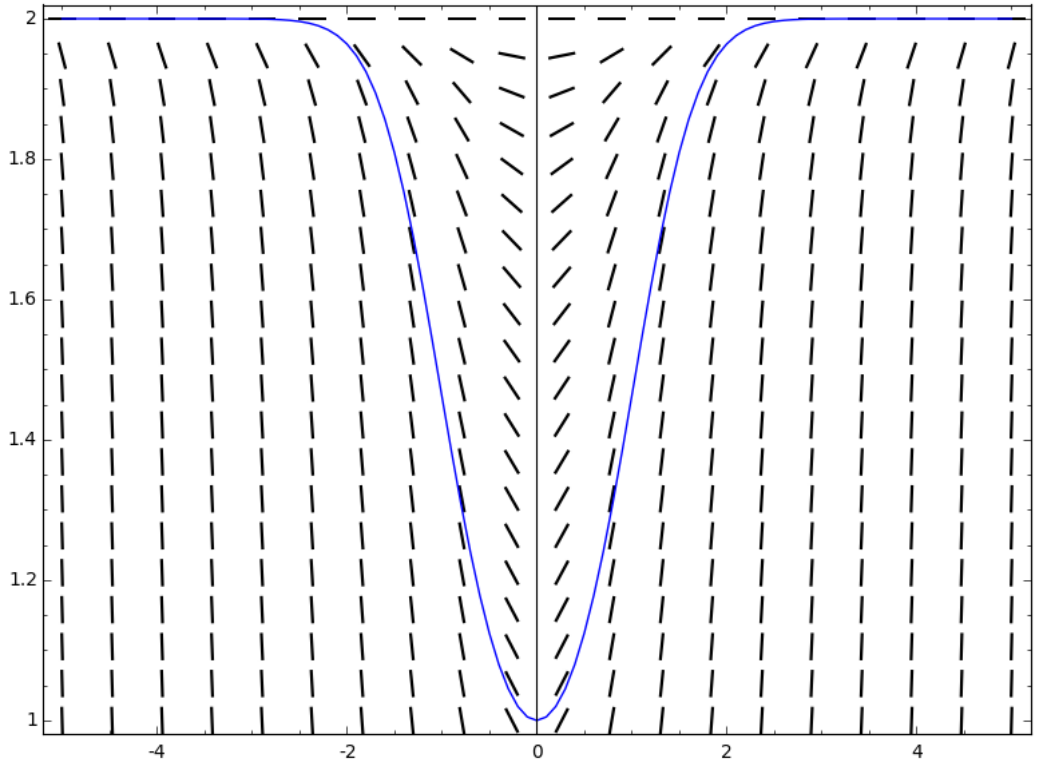
```
R6.<a0, a1, a2, a3, a4, a5, a6> = PolynomialRing(QQ,7)

R.<x> = PowerSeriesRing(R6)

y=a0 + a1*x+a2*x^2+a3*x^3+a4*x^4+a5*x^5+a6*x^6

x^2*diff(y,x,2) + x*diff(y,x) + x^2*y
```

```
a1*x + (a0 + 4*a2)*x^2 + (a1 + 9*a3)*x^3 + (a2 + 16*a4)*x^4 + (a3 +
25*a5)*x^5 + (a4 + 36*a6)*x^6 + a5*x^7 + a6*x^8
```

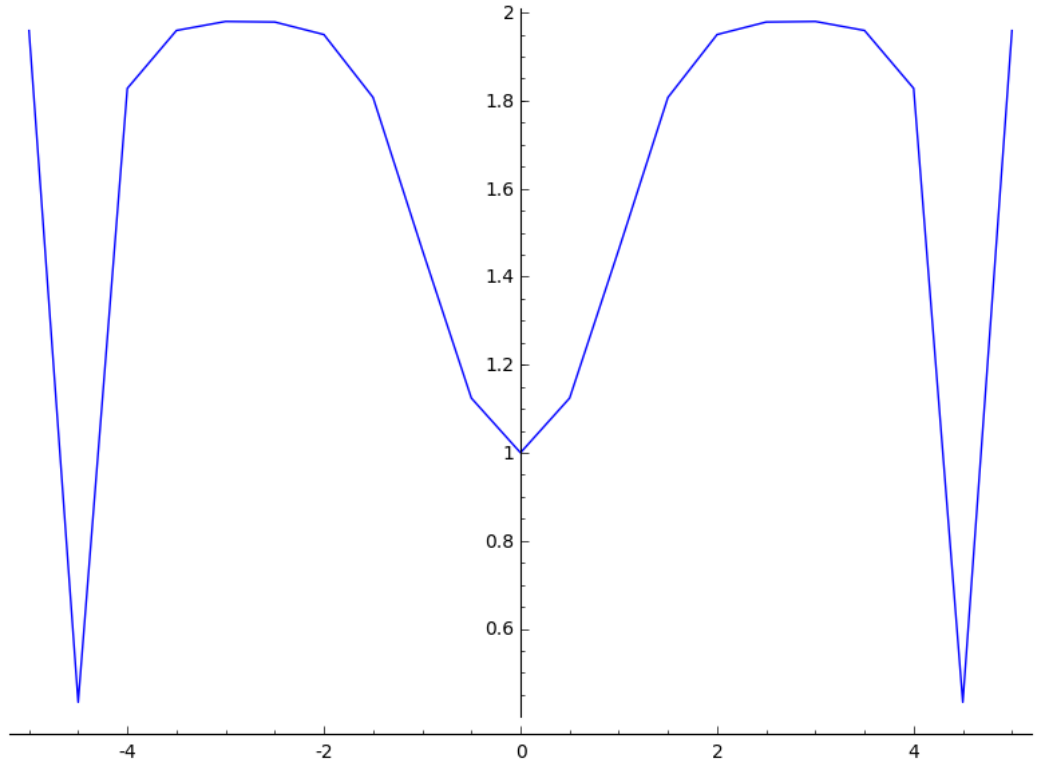
```
forget()
x=var('x')
y=function('y',x)
de12 = diff(y,x) ==  x*y*(2-y)
desolve_rk4(de12,y,ics=[0,1],end_points=[-5,5],step=0.5)
```

```
[[-5.0, 1.958884555282639],
 [-4.5, 0.4332725760124903],
 [-4.0, 1.827698497034663],
 [-3.5, 1.959201053585841],
 [-3.0, 1.979706489208877],
 [-2.5, 1.978424185560733],
 [-2.0, 1.94991313669415],
 [-1.5, 1.807111621208032],
 [-1.0, 1.461590162288825],
 [-0.5, 1.12419127424558],
 [0, 1],
 [0.5, 1.12419127424558],
 [1.0, 1.461590162288825],
 [1.5, 1.807111621208032],
 [2.0, 1.94991313669415],
 [2.5, 1.978424185560733],
 [3.0, 1.979706489208877],
 [3.5, 1.959201053585841],
 [4.0, 1.827698497034663],
 [4.5, 0.4332725760124903],
 [5.0, 1.958884555282639]]
```

```
forget()
x=var('x')
y=function('y',x)
de12 = diff(y,x) ==  x*y*(2-y)
desolve_rk4(de12,y,ics=[0,1],end_points=[-5,5],step=0.1,output='slope_field')
```




```
desolve_rk4(de12,y,ics=[0,1],end_points=[-5,5],step=0.5,output='plot')
```

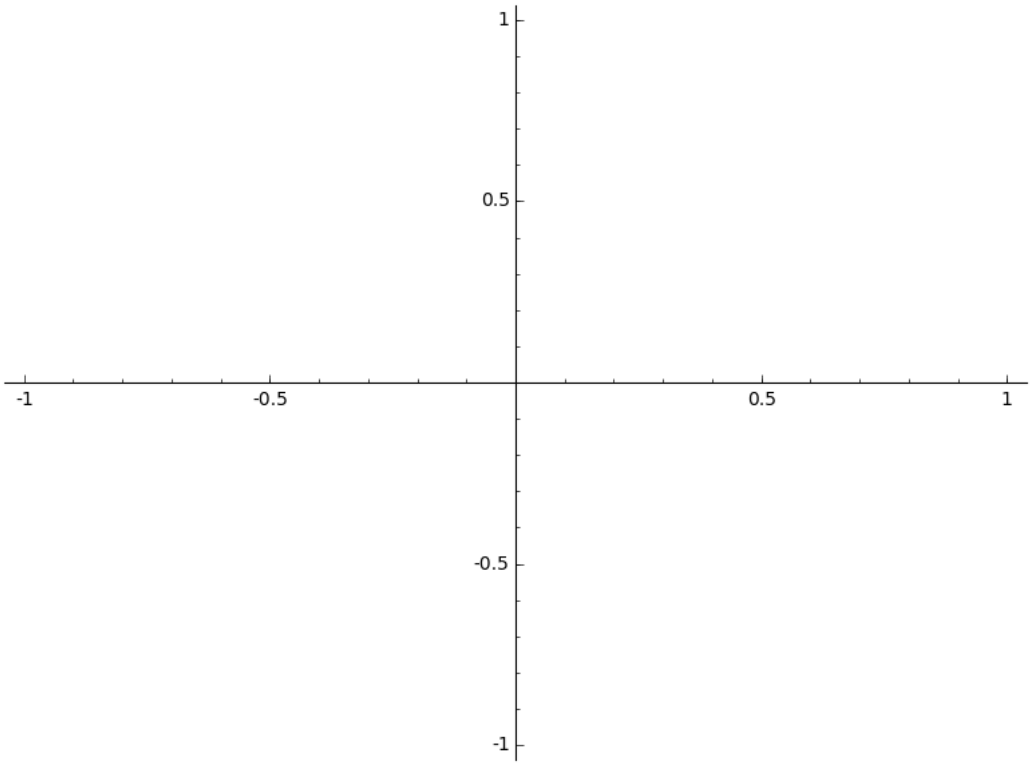



```
desolve(de12,y,ics=[0,1])
```

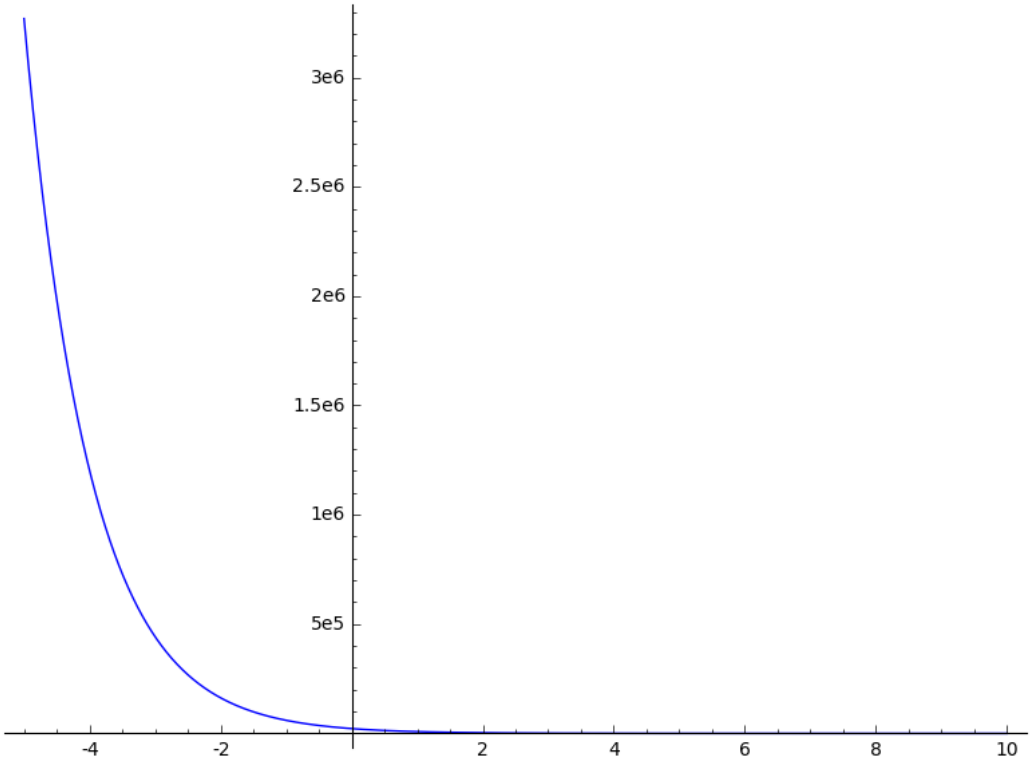
```
    -1/2*log(y(x) - 2) + 1/2*log(y(x)) == -1/2*I*pi + 1/2*x^2
```

```
plot(desolve(de12,y,ics=[0,1]),x,-1,1)
```

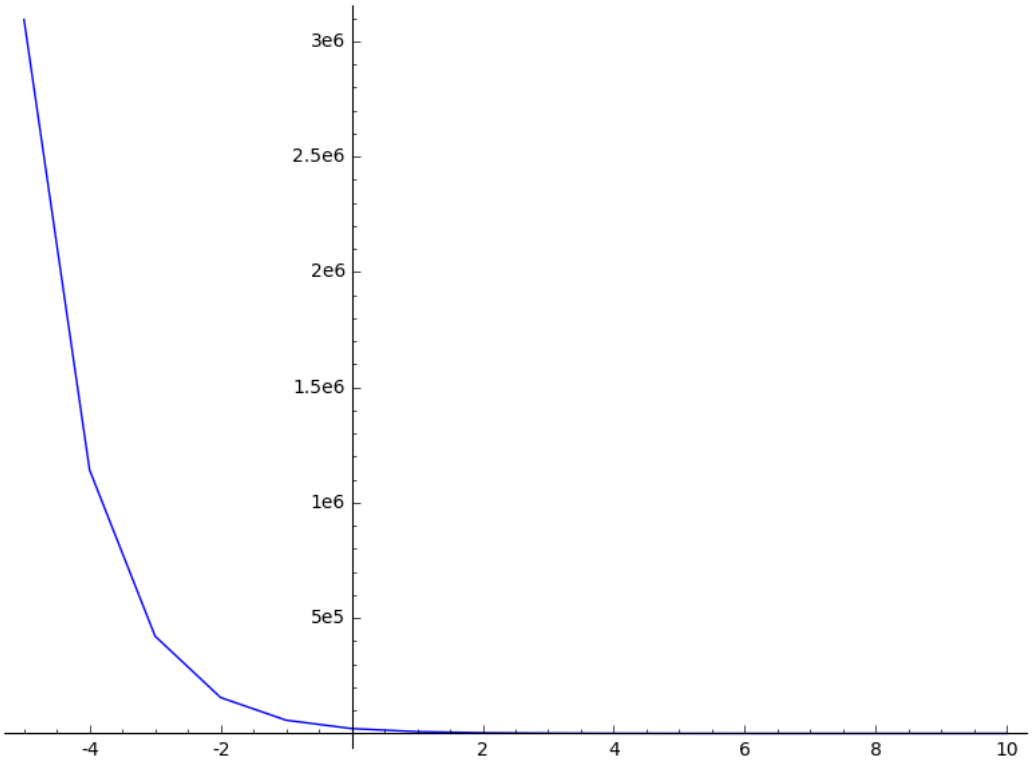
```
    verbose 0 (2716: plot.py, generate_plot_points) WARNING: When plotting,
    failed to evaluate function at 200 points.
    verbose 0 (2716: plot.py, generate_plot_points) Last error message:
    'unable to simplify to float approximation'
```




```
de1 = diff(y,x) + y - 1 == 0
plot(desolve(de1,y,ics=[10,2]),x,-5,10)
```




```
desolve_rk4(de1,y,ics=[10,2],end_points=[-5,5],step=1,output='plot')
```




```
from sage.calculus.desolvers import desolve_rk4_determine_bounds

desolve_rk4_determine_bounds(ics=[2,2], end_points=[-1,1])
```

```
(-1, 2)
```

```
x,y = PolynomialRing(QQ,2,"xy").gens()
eulers_method(5*x + y -5, 0, 1,1/2, 1, algorithm='table')
```

```
          x                   y                 h*f(x,y)
          0                   1                   -2
        1/2                  -1                 -7/4
          1               -11/4                -11/8
```

```
eulers_method(5*x + y -5, 0, 1,1/2, 1, algorithm='none')
```

```
[[0, 1], [1/2, -1], [1, -11/4], [3/2, -33/8]]
```

```
x,y = PolynomialRing(RR,2,"xy").gens()
eulers_method(5*x + y -5, 0, 1,1/2, 1, algorithm='table')
```

```
          x                   y                 h*f(x,y)
          0                   1    -2.00000000000000
        1/2    -1.00000000000000    -1.75000000000000
          1    -2.75000000000000    -1.37500000000000
```

```
x,y = PolynomialRing(CC,2,"xy").gens()
eulers_method(5*x + y -5, 0, 1,1/2, 1, algorithm='table')
```

```
          x                   y                 h*f(x,y)
          0                   1    -2.00000000000000
        1/2    -1.00000000000000    -1.75000000000000
          1    -2.75000000000000    -1.37500000000000
```

```
forget()
t=var('t')
x=function('x',t)
y=function('y',t)
desolve_system([diff(x,t) == 1-y, diff(y,t) == x-1], [x,y],  ivar=t)
```

```
[x(t) == (x(0) - 1)*cos(t) - sin(t) + 1,
 y(t) == (x(0) - 1)*sin(t) + cos(t) + 1]
```

```
t=var('t')
x=function('x',t)
y=function('y',t)
desolve_system([diff(x,t) == 1-y, diff(y,t) == x-1], [x,y],  ivar=t, ics=[0,1,2])
```

```
[x(t) == -sin(t) + 1, y(t) == cos(t) + 1]
```

```
t=var('t')
x=function('x',t)
y=function('y',t)
t,x,y = PolynomialRing (QQ, 3, "txy").gens()
desolve_system_rk4([ 1-y,  x-1], [x,y], ics=[0,1,2], ivar=t, end_points=10,step=0.1)
```

```
[[0, 1, 2],
 [0.1, 0.9001666666666667, 1.995004166666667],
 [0.2, 0.8013308347222222, 1.980066597239583],
 [0.3, 0.7044800374693374, 1.955336542863976],
 [0.4, 0.61058197441956, 1.921061097792607],
 [0.5, 0.5205748423760603, 1.877582730504437],
 [0.6000000000000001, 0.4353579612973303, 1.825335861877169],
 [0.7000000000000001, 0.355782788604945, 1.764842524603391],
 [0.8, 0.2826444117173009, 1.696707147219954],
 [0.9, 0.2166736038129712, 1.621610514866744],
 [1.0, 0.1585295221997256, 1.540302967116884],
 [1.1, 0.1087931222445672, 1.453596900843269],
 [1.2, 0.06796135267050071, 1.362358653030222],
 [1.3, 0.03644219021860052, 1.267499844634397],
 [1.4, 0.01455056328729948, 1.169968271984068],
 [1.5, 0.002505205278467241, 1.070738436726796],
 [1.6, 0.000426469090538404, 0.9708018089469489],
 [1.7, 0.00833512459550319, 0.8711569207406236],
 [1.8, 0.02615215111493923, 0.7727993892295413],
 [1.9, 0.05369952696857831, 0.6767119687004901],
 [2.0, 0.09070200820649885, 0.5838547312658869],
 [2.1, 0.1367898787524562, 0.4951554741568866],
 [2.2, 0.1915026444798595, 0.4115004494960314],
 [2.3, 0.2542936343104584, 0.3337255091743301],
 [2.4, 0.3245354623631451, 0.2626077533100741],
 [2.5, 0.4015262965769668, 0.1988577657350832],
 [2.6, 0.4844968711744319, 0.1431125140886988],
 [2.7, 0.5726181728990012, 0.0959289854593115],
 [2.8, 0.6650097242285387, 0.05777862116387131],
 [2.9, 0.7607483808017205, 0.02904260627112258],
 [3.0, 0.8588775551565648, 0.01000806093399819],
 [3.1, 0.9584167746206843, 0.000865171586045816],
 [3.2, 1.058371477854135, 0.001705290665962182],
 [3.3, 1.157742952161203, 0.01252002385711461],
 [3.4, 1.255538312280963, 0.03320131396202192],
 [3.5, 1.350780420951984, 0.06354252057373613],
 [3.6, 1.442517652128367, 0.1032404847564096],
 [3.7, 1.529833399296427, 0.1518985581054626],
 [3.8, 1.611855233888247, 0.2090305659220207],
 [3.9, 1.687763622284398, 0.2740656649029453],
 [4.0, 1.756800114308592, 0.3463540468100934],
 [4.100000000000001, 1.818274921397651, 0.4251734311297124],
 [4.2, 1.871573808728385, 0.509736281849559],
 [4.3, 1.916164232437632, 0.5991976762462027],
 [4.4, 1.9516006606145, 0.692663747060313],
 [4.5, 1.977529024899325, 0.7892006137086384],
 [4.600000000000001, 1.99369025821052, 0.8878437132951016],
 [4.7, 1.999922883251582, 0.9876074381887817],
 [4.800000000000001, 1.996164625934824, 1.087494983873447],
 [4.9, 1.982453037601059, 1.186508308672339],
 [5.0, 1.958925119818256, 1.283658105834102],
 [5.100000000000001, 1.925815955508059, 1.377973688342229],
 [5.2, 1.883456360077501, 1.46851268768244],
 [5.300000000000001, 1.832269576024983, 1.554370469661297],
 [5.4, 1.772767044046906, 1.634689173196442],
 [5.5, 1.705543292898577, 1.708666281766031],
 [5.600000000000001, 1.631269999068162, 1.775562641874416],
 [5.7, 1.550689275617355, 1.834709848416356],
 [5.800000000000001, 1.46460625724435, 1.885516923147776],
 [5.9, 1.373881055656614, 1.927476219534111],
 [6.0, 1.279420165632574, 1.960168494977074],
 [6.100000000000001, 1.18216740763989, 1.983267099739903],
 [6.2, 1.083094497508523, 1.996541240716834],
 [6.300000000000001, 0.9831913373831557, 1.999858287436354],
 [6.4, 0.8834561249644164, 1.993185097257455],
 [6.5, 0.7848853798639124, 1.976588346518021],
 [6.600000000000001, 0.6884639867262932, 1.950233864326621],
 [6.7, 0.5951553546039987, 1.914384975654265],
```

```
 [6.800000000000001, 0.5058917909088055, 1.869399870281358],
 [6.9, 0.4215651861203014, 1.815728023888473],
 [7.0, 0.3430181023264429, 1.75390570705014],
 [7.100000000000001, 0.2710353546363981, 1.684550627004259],
 [7.2, 0.2063361695812686, 1.608355755734717],
 [7.300000000000001, 0.1495669988532196, 1.526082406034889],
 [7.4, 0.1012950601856323, 1.438552624733586],
 [7.5, 0.06200266991155196, 1.34664097908772],
 [7.600000000000001, 0.03208242382752814, 1.251265818409197],
 [7.7, 0.01183327451397158, 1.153380098236843],
 [7.800000000000001, 0.001457544306067376, 1.053961858735046],
 [7.9, 0.001058903760589522, 0.9540044524556716],
 [8.0, 0.01064133581706103, 0.8545066191040439],
 [8.1, 0.03010909600298792, 0.7564625064785065],
 [8.200000000000001, 0.05926766908076875, 0.660851737290856],
 [8.3, 0.09782571257778229, 0.5686296211165371],
 [8.4, 0.1453979677805615, 0.480717609273391],
 [8.5, 0.2015091091073976, 0.3979940880004887],
 [8.6, 0.2655984933977664, 0.3212856019284082],
 [8.700000000000001, 0.337025761665314, 0.2513585955329845],
 [8.8, 0.4150772373436181, 0.1889117550890548],
 [8.9, 0.4989730570956649, 0.134569027640727],
 [9.0, 0.5878749629384585, 0.08887338674018906],
 [9.1, 0.6808946778265497, 0.05228140724562231],
 [9.200000000000001, 0.7771027810085532, 0.0251587033849416],
 [9.3, 0.875537994477168, 0.007776275666634896],
 [9.4, 0.9752167877257067, 0.0003078031380876011],
 [9.5, 1.075143204843741, 0.002827908046193296],
 [9.600000000000001, 1.174318815762931, 0.01531141023914603],
 [9.700000000000001, 1.271752692223641, 0.03763357875915892],
 [9.8, 1.366471308785951, 0.06957137811226809],
 [9.9, 1.4575282699576, 0.110805696762913],
 [10.0, 1.544013766248772, 0.1609245355869353]]
```

```
t=var('t')
x=function('x',t)
y=function('y',t)
t,x,y = PolynomialRing (QQ, 3, "txy").gens()
desolve_system_rk4([x*( 1-y), -y*( x-1)], [x,y], ics=[0,0.5,2], ivar=t, end_points=10,step=0.5)
```

```
[[0, 0.500000000000000, 2],
 [0.5, 0.2592749737668782, 2.731931223766878],
 [1.0, 0.08381181869088677, 4.159831105800261],
 [1.5, 0.03036496486737937, 6.749428008461739],
 [2.0, 0.1140108761050079, 11.18996636203008],
 [2.5, 3.726275194583882, 21.9842955659135],
 [3.0, -38058.46123938399, -38028.36403392813],
 [3.5, -2.39313067749154e+64, -2.39313067749154e+64]]
```

```
eulers_method_2x2(1-y, x-1, 0, 1 ,2, 0.1, 1, algorithm='none')
```

```
[[0, 1, 2],
 [0.100000000000000, 0.900000000000000, 2.00000000000000],
 [0.200000000000000, 0.800000000000000, 1.99000000000000],
 [0.300000000000000, 0.701000000000000, 1.97000000000000],
 [0.400000000000000, 0.604000000000000, 1.94010000000000],
 [0.500000000000000, 0.509990000000000, 1.90050000000000],
 [0.600000000000000, 0.419940000000000, 1.85149900000000],
 [0.700000000000000, 0.334790100000000, 1.79349300000000],
 [0.800000000000000, 0.255440800000000, 1.72697201000000],
 [0.900000000000000, 0.182743599000000, 1.65251609000000],
 [1.00000000000000, 0.117491990000000, 1.57079044990000],
 [1.10000000000000, 0.0604129450100001, 1.48253964890000]]
```

```
eulers_method_2x2( x-1, 1-y, 0, 1 ,2, 0.1, 1, algorithm='none')
```

```
[[0, 1, 2],
 [0.100000000000000, 1.00000000000000, 1.90000000000000],
 [0.200000000000000, 1.00000000000000, 1.81000000000000],
 [0.300000000000000, 1.00000000000000, 1.72900000000000],
 [0.400000000000000, 1.00000000000000, 1.65610000000000],
 [0.500000000000000, 1.00000000000000, 1.59049000000000],
 [0.600000000000000, 1.00000000000000, 1.53144100000000],
 [0.700000000000000, 1.00000000000000, 1.47829690000000],
 [0.800000000000000, 1.00000000000000, 1.43046721000000],
 [0.900000000000000, 1.00000000000000, 1.38742048900000],
 [1.00000000000000, 1.00000000000000, 1.34867844010000],
 [1.10000000000000, 1.00000000000000, 1.31381059609000]]
```

```
forget()
x=var('x')
taylor(e^x,x,2,5)
```

```
1/120*(x - 2)^5*e^2 + 1/24*(x - 2)^4*e^2 + 1/6*(x - 2)^3*e^2 + 1/2*(x -
2)^2*e^2 + (x - 2)*e^2 + e^2
```

```
show(taylor(e^x,x,2,5))
```

$$\frac{1}{120}\,(x-2)^5e^2+\frac{1}{24}\,(x-2)^4e^2+\frac{1}{6}\,(x-2)^3e^2+\frac{1}{2}\,(x-2)^2e^2+(x-2)e^2+e^2$$

```
show(taylor(e^(i*x),x,1,8))
```

$$\frac{1}{40320}\,(x-1)^8e^i-\frac{1}{5040}i\,(x-1)^7e^i-\frac{1}{720}\,(x-1)^6e^i+\frac{1}{120}i\,(x-1)^5e^i+\frac{1}{24}\,(x-1)^4e^i-\frac{1}{6}i\,(x-1)^3e^i-\frac{1}{2}\,(x-1)^2e^i+i\,(x-1$$

```
show(taylor(sin(x),x,1,8))
```

$$\frac{1}{40320}\,(x-1)^8\sin(1)-\frac{1}{5040}\,(x-1)^7\cos(1)-\frac{1}{720}\,(x-1)^6\sin(1)+\frac{1}{120}\,(x-1)^5\cos(1)+\frac{1}{24}\,(x-1)^4\sin(1)-\frac{1}{6}\,(x-1)^3\cos($$

```
show(taylor(sin(x),x,0,8))
```

$$-\frac{1}{5040}\,x^7+\frac{1}{120}\,x^5-\frac{1}{6}\,x^3+x$$

```
show(taylor(1/(1-x),x,0,9))
```

evaluate

$$x^9+x^8+x^7+x^6+x^5+x^4+x^3+x^2+x+1$$