Application Demonstration

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The direct search optimization package v.2 for Maple

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▶ Introduction

▶ What's new in DirectSearch package, Version 2

▶ Package installation instruction

```
> restart; interface(version);
```

Standard Worksheet Interface, Maple 18.01, Windows 7, March 28 2014 Build ID 935137 (1)

```
> libname:= "D:\\_Work\\Maple_Work\\z_Packages\\DirectSearch",
  libname;
```

libname := "D:_Work\Maple_Work\z_Packages\DirectSearch", (2)
"D:_Work\Maple_Work\z_Packages\myLib\", "C:\programs_x86\Maple18\lib", "."

```
> #restart:
  with(DirectSearch);
```

[*BoundedObjective, CompromiseProgramming, DataFit, ExponentialWeightedSum,* (3)
GlobalOptima, GlobalSearch, Minimax, ModifiedTchebycheff, Search, SolveEquations,
WeightedProduct, WeightedSum]

```
> ?DirectSearch;
```

▶ Local search

▶ Constrained optimization

Mixed integer-discrete-continuous optimization

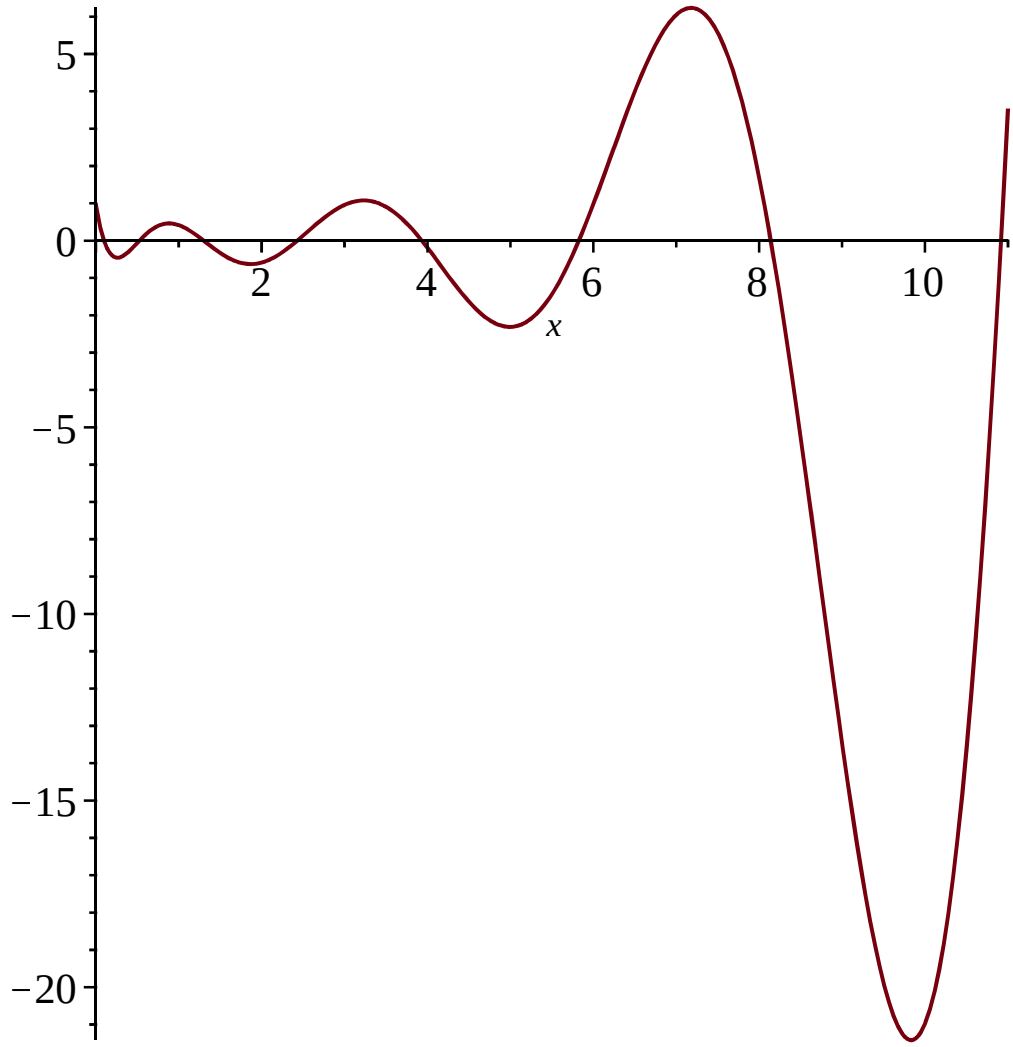
Search one global optimum

Find the global minimum of the 14-th Laguerre polynomial. This polynomial has one global (f= -1.37789...*10^8, x=42.524447...) and some local minimums.

```
> f:=LaguerreL(14,x);
```

$$f := \mathrm{LaguerreL}(14, x) \tag{7.1}$$

```
> plot(f,x=0..11);
```




```
> Search(f,strategy=globalsearch);
```

$$[-1.37789287589033\ 10^{8}, [x = 42.5244475347538], 190] \tag{7.2}$$

```
> GlobalOptima(f);
```

$$[-1.37789287589033\ 10^{8}, [x = 42.5244475354787], 193] \tag{7.3}$$

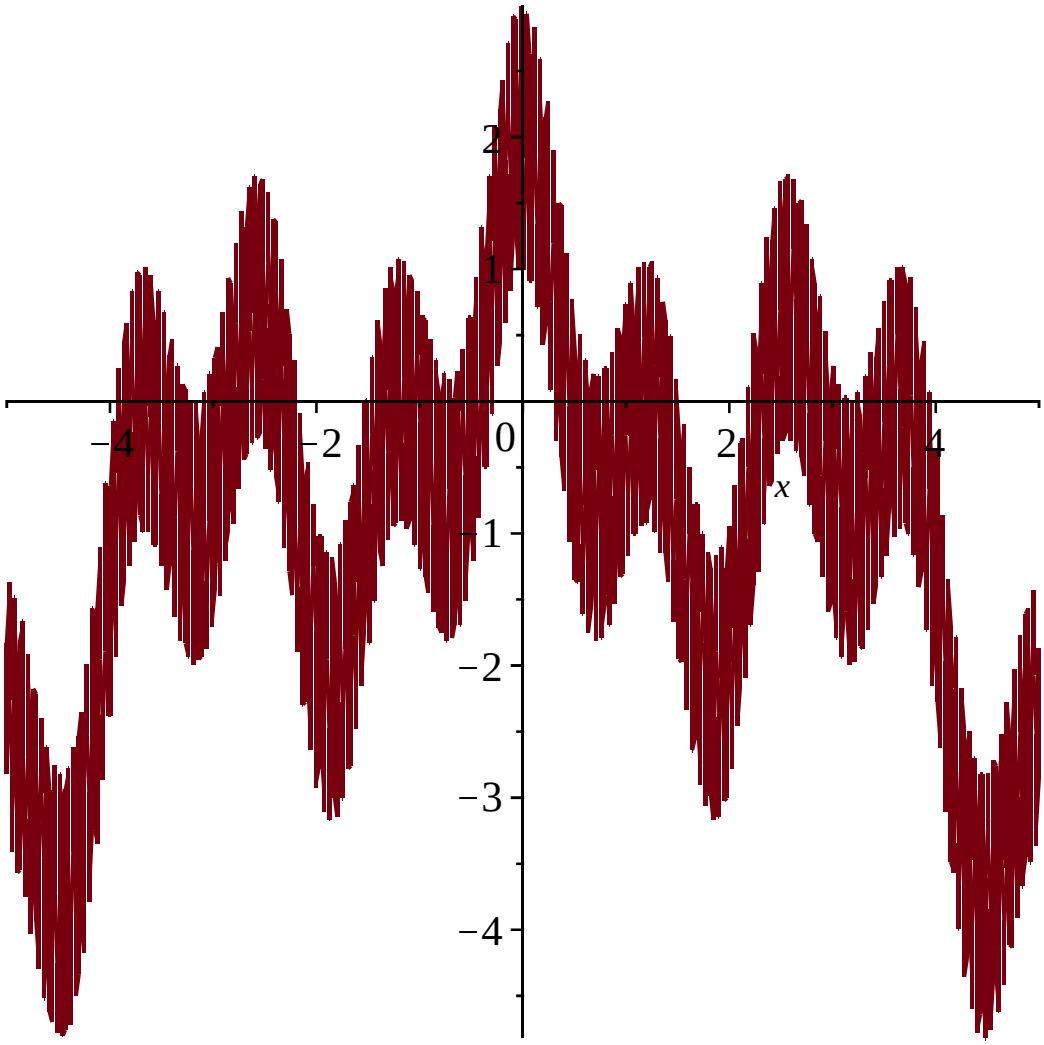
Find the global minimum of the following function in range -5..5. This function has one global (f=-4.819033..., x=4.4767...) and many local minimums.

```
> f:=-x^2/10-sin(100*x)+cos(2*x)+cos(5*x);
  constr:=[x=-5..5];
```

$$f := -\frac{1}{10}x^{2} - \sin(100\,x) + \cos(2\,x) + \cos(5\,x) \tag{7.4}$$

$$constr := [x = -5..5] \quad \textbf{(7.4)}$$

```
> plot(f,x=-5..5,numpoints=1000);
```



Search command with option **strategy=globalsearch** not always finds the global minimum. The **GlobalOptima** command is more reliable although it is more slowly.

```
> Search(f,constr,strategy=globalsearch);
```

$$[-4.80925611408668, [x = -4.44542739487285], 202] \quad \textbf{(7.5)}$$

```
> GlobalOptima(f,constr,pointrange=constr);
```

$$[-4.81903320470201, [x = 4.47675855219007], 170] \quad \textbf{(7.6)}$$

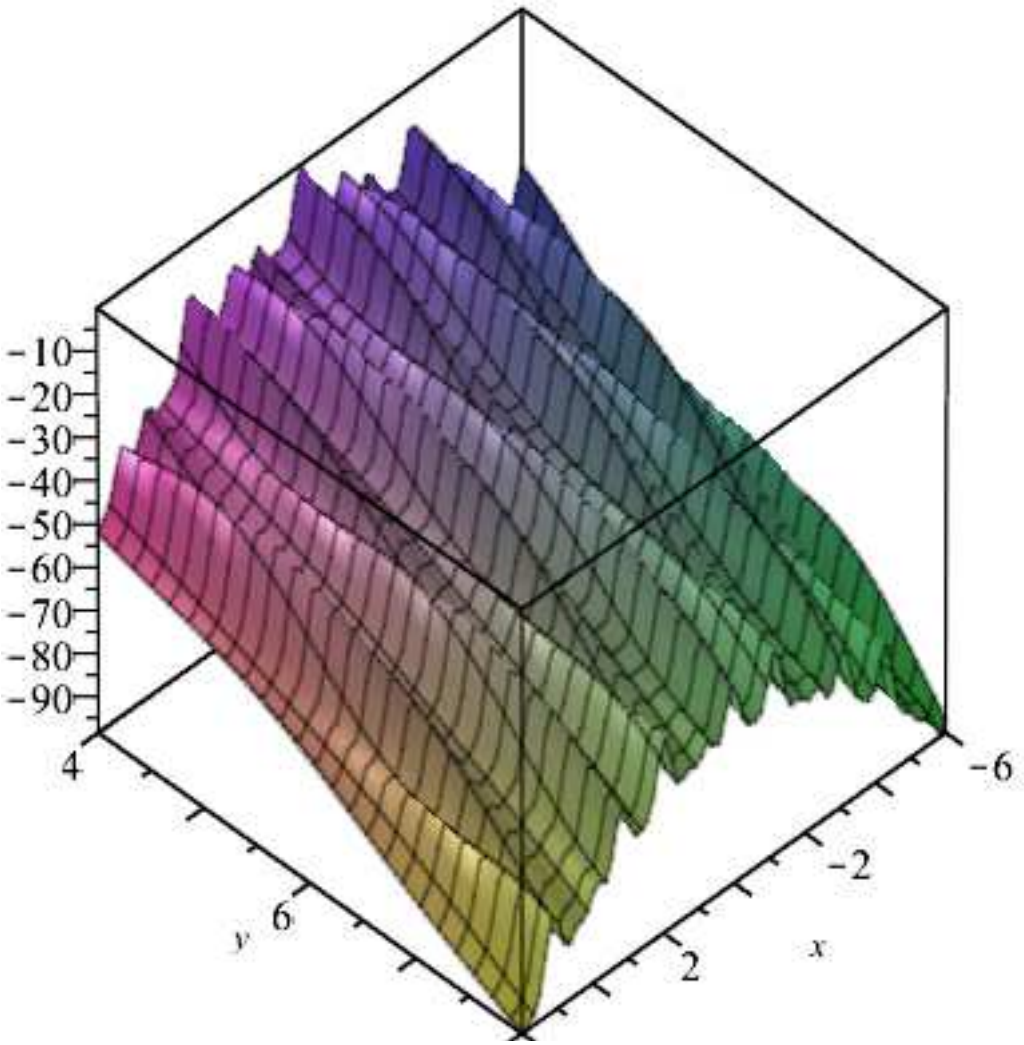
Find the global maximum of the following function with given constraints. This function has one global maximum(f=-0.1648..., [x=0.25100...,y=4]) and some local maximums.

```
> f:=(x,y)->(4*sin(1+2*x)*sin(3*x+y))^2-x^2-y^2;
  constr:=[x=-6..6,y>=4];
```

$$f := (x, y) \rightarrow 16 \sin(1 + 2x)^2 \sin(3x + y)^2 - x^2 - y^2$$

$$constr := [x = -6..6, 4 \le y] \quad \textbf{(7.7)}$$

```
> plot3d(f(x,y),x=-6..6,y=4..8,numpoints=5000);
```




```
> Search(f,constr,strategy=globalsearch,maximize);
```

Warning, initial point [x = .900000000000000, y = .900000000000000] does not satisfy the inequality constraints; trying to find a feasible initial point

Warning, the new feasible initial point is [x = -3.12690680582748, y = 4.525380988585801]

$$\left[-0.164857779671120,\ \begin{bmatrix} 0.250971874649130 \\ 4.00000000000896 \end{bmatrix},\ 285\right] \tag{7.8}$$

```
> GlobalOptima(f,constr,maximize);
```

$$\left[-0.164857488104467,\ \begin{bmatrix} 0.251009488804561 \\ 4.00000000004720 \end{bmatrix},\ 319\right] \tag{7.9}$$

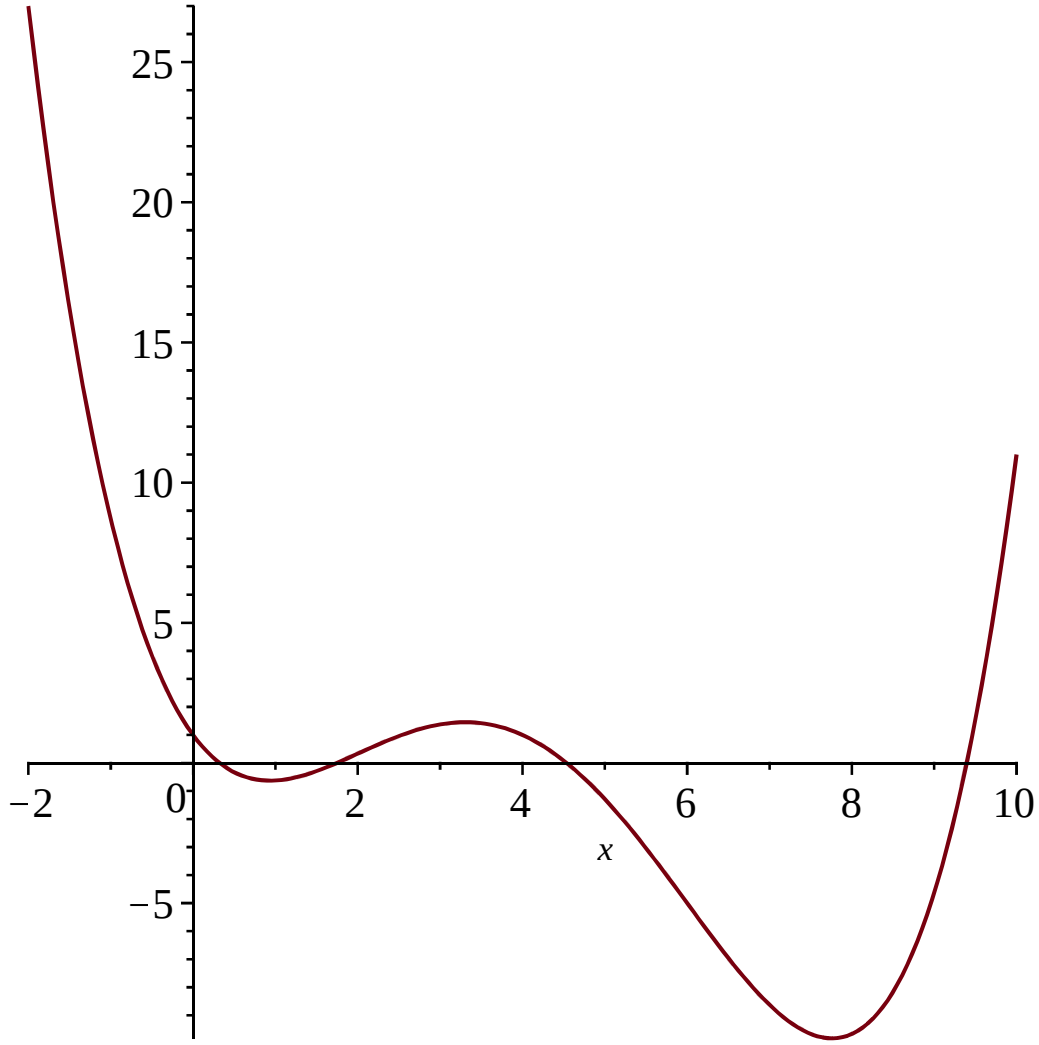
Search all local and global optimums

Find all minimums of the 4-th Laguerre polynomial. This polynomial has one global and one local minimum.

```
> f:=LaguerreL(4,x);
```

$$f := \mathrm{LaguerreL}(4, x) \tag{8.1}$$

```
> plot(f,x=-2..10);
```




```
> GlobalSearch(f);
```

$$\begin{bmatrix} -9.82294825561955 & [x = 7.75877047837731] & 39 \\ -0.630414938191809 & [x = 0.935822212196263] & 23 \end{bmatrix} \quad \textbf{(8.2)}$$

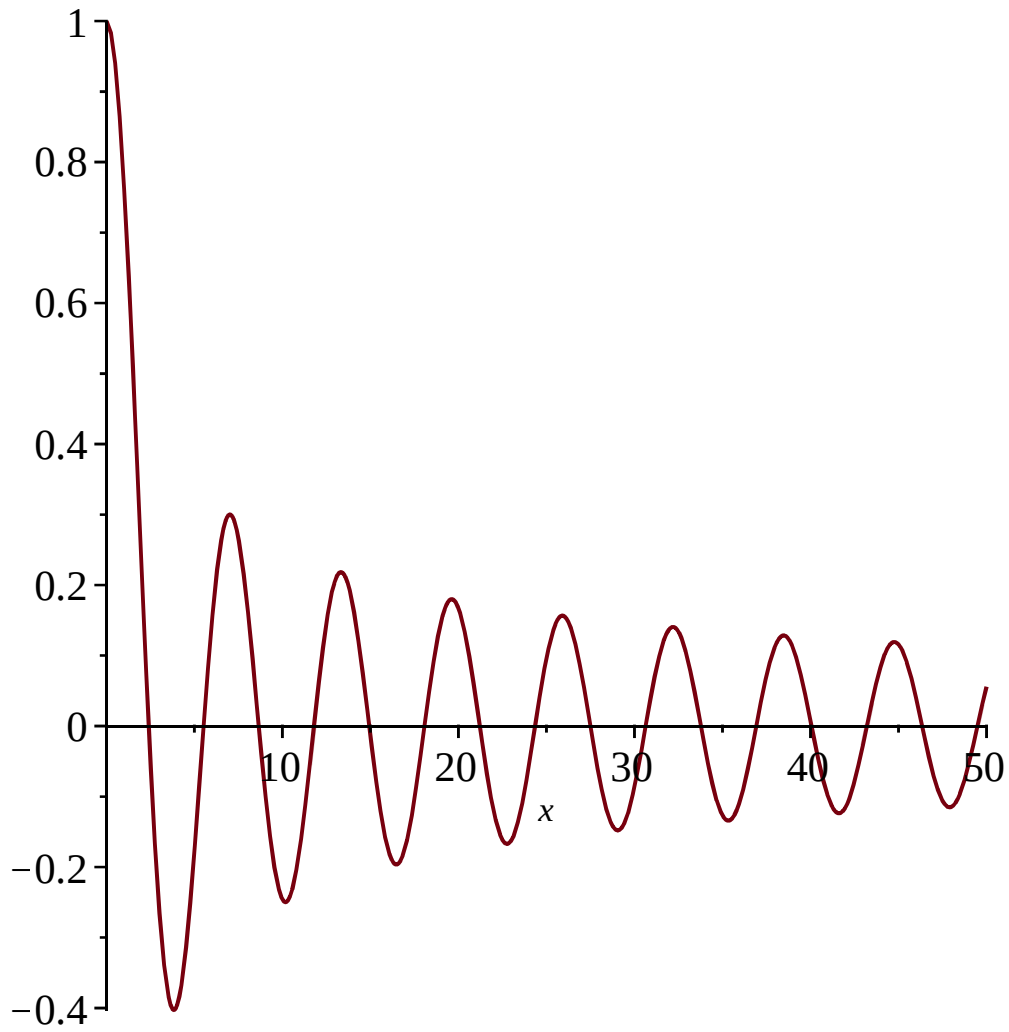
Find all minimums of the BesselJ function in range 0..50. This function has one global and 7 local minimums.

```
> f:=BesselJ(0,x);
  constr:=[x=0..50];
```

$$f := \mathrm{BesselJ}(0, x)$$

$$constr := [x = 0..50] \quad \textbf{(8.3)}$$

```
> plot(f,x=0..50);
```



The found solutions are always ranged from the best to the worst

```
> sol:=GlobalSearch(f,constr,pointrange=constr);
```

$$sol := \begin{bmatrix} -0.402759395702553 & [x = 3.83170597828414] & 24 \\ -0.249704877057843 & [x = 10.1734681411632] & 16 \\ -0.196465371468657 & [x = 16.4706300657352] & 28 \\ -0.167184600473818 & [x = 22.7600843916289] & 23 \\ -0.148011109972778 & [x = 29.0468285336181] & 17 \\ -0.134211240310001 & [x = 35.3323075573619] & 23 \\ -0.123667960769837 & [x = 41.6170942157057] & 10 \\ -0.115273694120168 & [x = 47.9014608830298] & 20 \end{bmatrix} \quad \textbf{(8.4)}$$

The global minimum is always the first solution.

```
> sol[1];
```

$$\begin{bmatrix} -0.402759395702553 & [x = 3.83170597828414] & 24 \end{bmatrix} \quad \textbf{(8.5)}$$

Extract the global minimum value and point

```
> sol[1,1];sol[1,2];
```

$$-0.402759395702553$$

$$[x = 3.83170597828414] \quad \textbf{(8.6)}$$

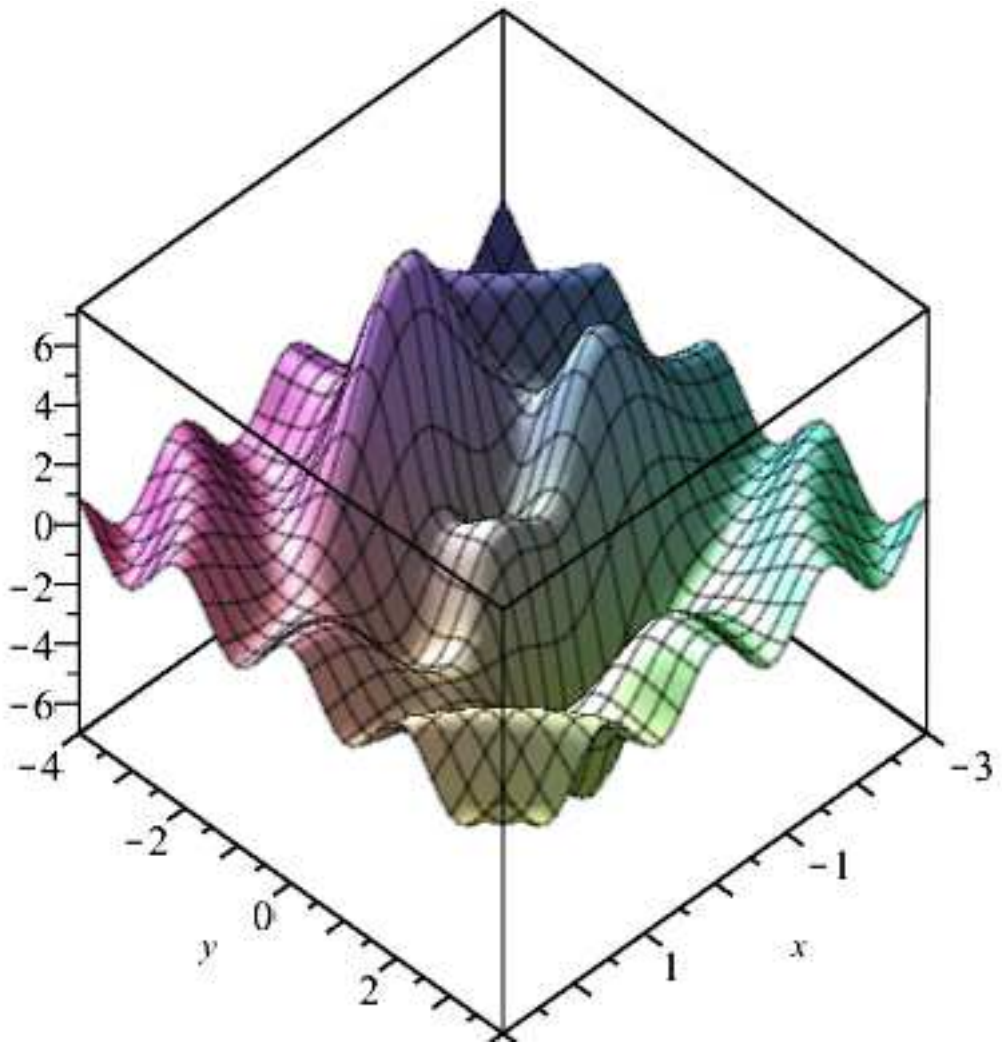
Find the best five minimums of the following function in range x=-3..3, y=-4..4. This function has one global (f=-7.10629975...) and many local minimums.

```
> f:=-3*(1-x)*exp(-x^2-(y+1)^2)+10*(0.2*x-x^3-y^5)*exp(-x^2-
  y^2)+exp(-(x+1)^2-y^2)/3+cos(x*y);
  constr:=[x=-3..3,y=-4..4];
```

$$f := -3\,(1-x)\,e^{-x^2-(y+1)^2} + 10\,(0.2\,x - x^3 - y^5)\,e^{-x^2-y^2} + \frac{1}{3}\,e^{-(x+1)^2-y^2} + \cos(x\,y)$$

$$constr := [x = -3..3,\ y = -4..4] \qquad \textbf{(8.7)}$$

```
> plot3d(f,x=-3..3,y=-4..4);
```




```
> GlobalSearch(f,constr,pointrange=constr,solutions=5);
```

-7.10629975630783	[x = -0.0107231196020700, y = 1.58135880323709]	75
-2.51665464519379	[x = 1.27695000978897, y = 0.0212276642598472]	61
-1.65709172827052	[x = -0.297067190414203, y = -0.542723718651539]	75
-1.04678267464566	[x = 2.36548697743648, y = -1.28143740578732]	93
-1.00002226833890	[x = 2.89197243342691, y = 3.25893109034163]	170

(8.8)

Find all minimums of the following function with constraint. The function has two global minimum (f=2, x=1, x=-1)

```
> f:=x->1/x^2+x^2;
  constr:={x<>0};
```

$$f := x \to \frac{1}{x^2} + x^2$$

$$constr := \{x \neq 0\} \tag{8.9}$$

```
> GlobalSearch(f,constr);
```

$$\begin{bmatrix} 2. & [\ 1.00000000000219\ ] & 30 \\ 2. & [\ -1.00000000477131\ ] & 30 \end{bmatrix} \tag{8.10}$$

▶ Multiobjective optimization

▶ Solve system of equations

▶ Fit function to data

For more examples see package Help