In[1]:=
```
Get[FileNameJoin[{NotebookDirectory[], "DeStrelba.wl"}]]
```

Aplikační příklad 6

Apl. příklad 6: Jednoduchý model chování sloupce plasmy stlačované zářením odvodil Troesch ve tvaru nelineární okrajové úlohy

$\frac{\partial^2 y}{\partial x^2} = \alpha \sinh(\alpha y)$,

$y(0) = 0,\ y(1) = 1.$

Použijte parametry α=0,8; 1; 2; 5; 10; 20.

$\alpha = 0.8$

Definice parametrů diferenciální rovnice

In[2]:=
```
α = 0.8;
```

Definice pravé strany diferenciální rovnice

In[3]:=
```
f[x_, y1_, y2_] = y2;
g[x_, y1_, y2_] = α Sinh[α y1];
```

Parametry programu Strelba2

In[5]:=
```
a = 0.0;
b = 1.0;
α1 = 1;
α2 = 1;
β1 = 0;
β2 = 0;
γ1 = 0;
γ2 = 1;
ϵ = 0.000001;
z0 = 1.0;
m = 10;
Lx = Table[N[a + i (b - a) / m], {i, 0, m}];
```

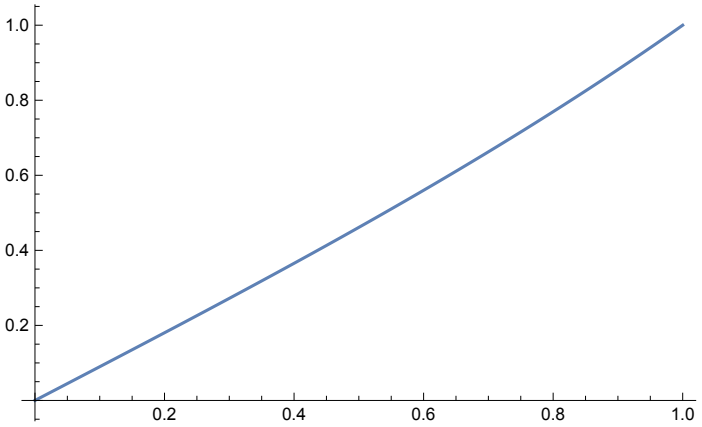
In[17]:=
```
v = Strelba2[f, g, a, b, α1, α2 , β1, β2 , γ1 , γ2 , ϵ, z0, Lx];
```

i	z	s
0	1.	
1	0.898231	0.101769
2	0.898115	0.000115411
3	0.898115	1.39111×10^{-10}

Graf řešení $y_1(x)$

In[18]:=
```
v[[1]]
```

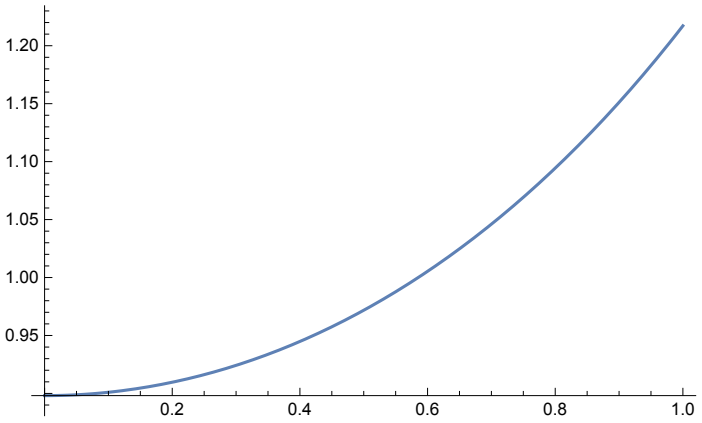
Out[18]=



Graf řešení $y_2(x)$

In[19]:=
```
v[[2]]
```

Out[19]=



Tabulka řešení $y_1(x)$

In[20]:=
```
MatrixForm[v[[3]]]
```

Out[20]//MatrixForm=

0.	0.
0.1	0.0899074
0.2	0.180391
0.3	0.272035
0.4	0.365435
0.5	0.461209
0.6	0.560007
0.7	0.662513
0.8	0.769466
0.9	0.881668
1.	1.

Tabulka řešení $y_2(x)$

In[21]:=
```
MatrixForm[v[[4]]]
```

Out[21]//MatrixForm=

0.	0.898115
0.1	0.900992
0.2	0.909656
0.3	0.924208
0.4	0.944822
0.5	0.971751
0.6	1.00534
0.7	1.04602
0.8	1.09438
0.9	1.15112
1.	1.21716

$\alpha = 1.0$

Definice parametrů diferenciální rovnice

In[22]:=
```
α = 1.0;
```

Definice pravé strany diferenciální rovnice

In[23]:=
```
f[x_, y1_, y2_] = y2;
g[x_, y1_, y2_] = α Sinh[α y1];
```

Parametry programu Strelba2

In[25]:=
```
a = 0.0;
b = 1.0;
α1 = 1;
α2 = 1;
β1 = 0;
β2 = 0;
γ1 = 0;
γ2 = 1;
ϵ = 0.000001;
z0 = 1.0;
m = 10;
Lx = Table[N[a + i (b - a) / m], {i, 0, m}];
```

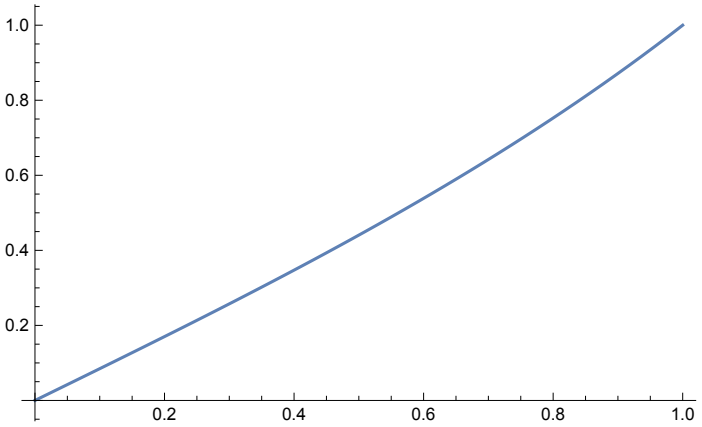
In[37]:=
```
v = Strelba2[f, g, a, b, α1, α2 , β1, β2 , γ1 , γ2 , ϵ, z0, Lx];
```

i	z	s
0	1.	
1	0.845888	0.154112
2	0.845203	0.000684959
3	0.845203	1.17771×10^{-8}

Graf řešení $y_1(x)$

In[38]:=
```
v[[1]]
```

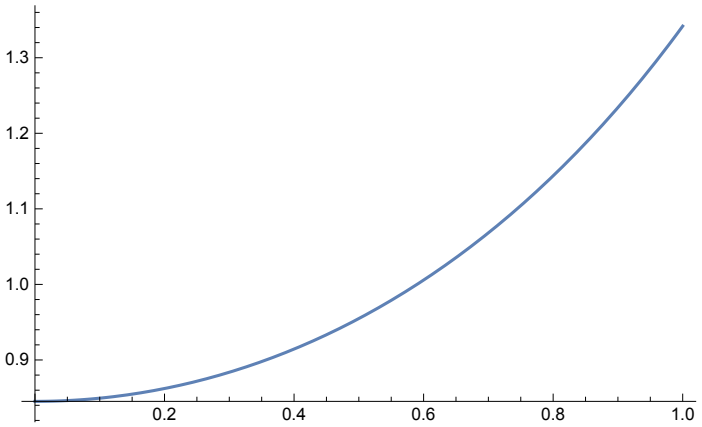
Out[38]=



Graf řešení $y_2(x)$

In[39]:=
```
v[[2]]
```

Out[39]=



Tabulka řešení $y_1(x)$

In[40]:=
```
MatrixForm[v[[3]]]
```

Out[40]//MatrixForm=

0.	0.
0.1	0.0846612
0.2	0.170171
0.3	0.257394
0.4	0.347223
0.5	0.4406
0.6	0.538534
0.7	0.642129
0.8	0.752608
0.9	0.871363
1.	1.

Tabulka řešení $y_2(x)$

In[41]:=
```
MatrixForm[v[[4]]]
```

Out[41]//MatrixForm=

0.	0.845203
0.1	0.849435
0.2	0.862204
0.3	0.883734
0.4	0.914411
0.5	0.954807
0.6	1.00572
0.7	1.0682
0.8	1.14369
0.9	1.23406
1.	1.34184

$\alpha = 2.0$

Definice parametrů diferenciální rovnice

In[42]:=
```
α = 2.0;
```

Definice pravé strany diferenciální rovnice

In[43]:=
```
f[x_, y1_, y2_] = y2;
g[x_, y1_, y2_] = α Sinh[α y1];
```

Parametry programu Strelba2

In[45]:=
```
a = 0.0;
b = 1.0;
α1 = 1;
α2 = 1;
β1 = 0;
β2 = 0;
γ1 = 0;
γ2 = 1;
ϵ = 0.000001;
z0 = 1.0;
m = 10;
Lx = Table[N[a + i (b - a) / m], {i, 0, m}];
```

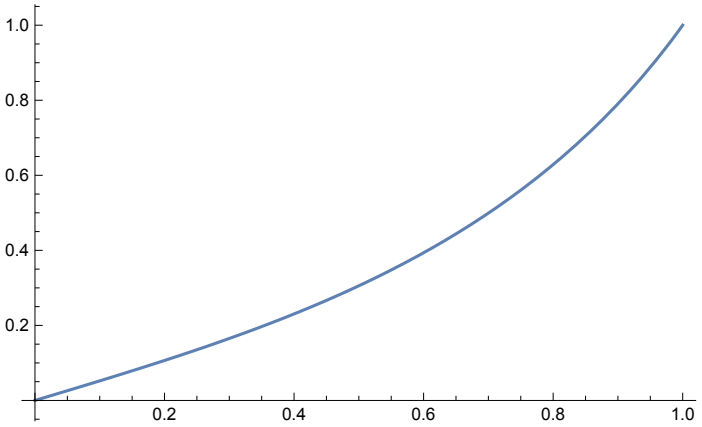
In[57]:=
```
v = Strelba2[f, g, a, b, α1, α2 , β1, β2 , γ1 , γ2 , ϵ, z0, Lx];
```

i	z	s
0	1.	
1	0.728782	0.271218
2	0.544211	0.184571
3	0.518902	0.0253084
4	0.518621	0.000281257
5	0.518621	3.26142×10^{-8}

Graf řešení $y_1(x)$

In[58]:=
```
v[[1]]
```

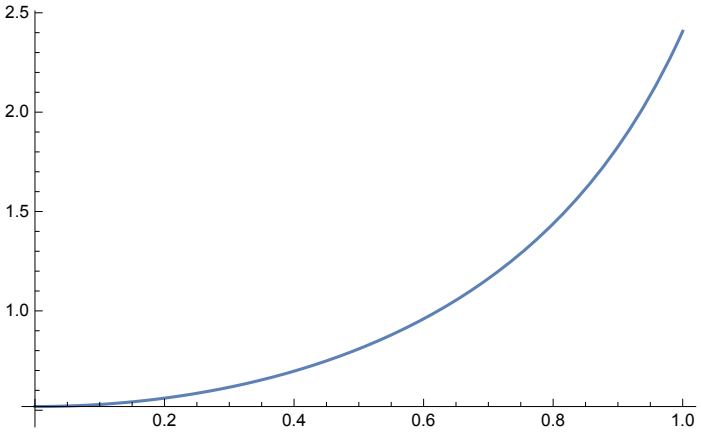
Out[58]=



Graf řešení $y_2(x)$

In[59]:=
```
v[[2]]
```

Out[59]=



Tabulka řešení $y_1(x)$

In[60]:=
```
MatrixForm[v[[3]]]
```

Out[60]//MatrixForm=

0.	0.
0.1	0.0522087
0.2	0.106519
0.3	0.165141
0.4	0.230522
0.5	0.305505
0.6	0.393563
0.7	0.499173
0.8	0.628465
0.9	0.790494
1.	1.

Tabulka řešení $y_2(x)$

In[61]:=
```
MatrixForm[v[[4]]]
```

Out[61]//MatrixForm=

0.	0.518621
0.1	0.529038
0.2	0.560825
0.3	0.61567
0.4	0.69665
0.5	0.80874
0.6	0.959788
0.7	1.16243
0.8	1.43809
0.9	1.82606
1.	2.40694

$\alpha = 5.0$

Definice parametrů diferenciální rovnice

In[62]:=
```
α = 5.0;
```

Definice pravé strany diferenciální rovnice

In[63]:=
```
f[x_, y1_, y2_] = y2;
g[x_, y1_, y2_] = α Sinh[α y1];
```

Parametry programu Strelba2

In[65]:=
```
a = 0.0;
b = 1.0;
α1 = 1;
α2 = 1;
β1 = 0;
β2 = 0;
γ1 = 0;
γ2 = 1;
ϵ = 0.000001;
z0 = 0.05;
m = 10;
Lx = Table[N[a + i (b - a) / m], {i, 0, m}];
```

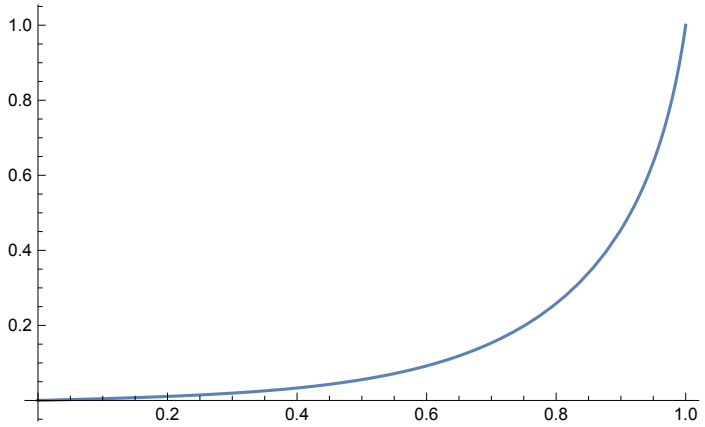
In[77]:=
```
v = Strelba2[f, g, a, b, α1, α2 , β1, β2 , γ1 , γ2 , ϵ, z0, Lx];
```

```
i      z            s
0      0.05
1      0.0470633      0.00293671
2      0.0458541      0.00120919
3      0.0457511      0.000103044
4      0.0457505      6.04957×10^-7
```

Graf řešení $y_1(x)$

In[78]:=
```
v[[1]]
```

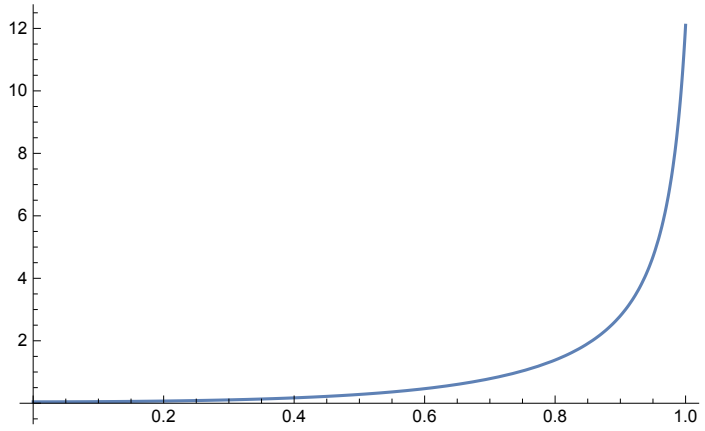
Out[78]=



Graf řešení $y_2(x)$

In[79]:=
```
v[[2]]
```

Out[79]=



Tabulka řešení $y_1(x)$

In[80]:=
```
MatrixForm[v[[3]]]
```

Out[80]//MatrixForm=

0.	0.
0.1	0.00476808
0.2	0.0107534
0.3	0.0194853
0.4	0.0332005
0.5	0.0554374
0.6	0.0920445
0.7	0.153162
0.8	0.258217
0.9	0.455061
1.	1.

Tabulka řešení $y_2(x)$

In[81]:=
```
MatrixForm[v[[4]]]
```

Out[81]//MatrixForm=

0.	0.0457505
0.1	0.0515897
0.2	0.0706024
0.3	0.107669
0.4	0.172376
0.5	0.281814
0.6	0.466544
0.7	0.785992
0.8	1.3834
0.9	2.79924
1.	12.1006

$\alpha = 10.0$

Definice parametrů diferenciální rovnice

In[82]:=
```
α = 10.0;
```

Definice pravé strany diferenciální rovnice

In[83]:=
```
f[x_, y1_, y2_] = y2;
g[x_, y1_, y2_] = α Sinh[α y1];
```

Parametry programu Strelba2

In[85]:=
```
a = 0.0;
b = 1.0;
α1 = 1;
α2 = 1;
β1 = 0;
β2 = 0;
γ1 = 0;
γ2 = 1;
ϵ = 0.000001;
z0 = 0.00035;
m = 10;
Lx = Table[N[a + i (b - a) / m], {i, 0, m}];
```

Museli jsme zvolit hodně přesný nástřel

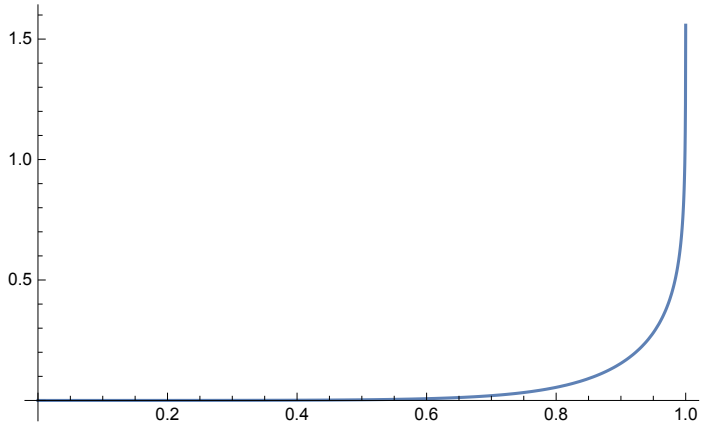
In[97]:=
```
v = Strelba2[f, g, a, b, α1, α2 , β1, β2 , γ1 , γ2 , ϵ, z0, Lx];
```

i	z	s
0	0.00035	
1	0.000363094	0.0000130944
2	0.000362691	4.03278×10^{-7}

Graf řešení $y_1(x)$

In[98]:=
```
v[[1]]
```

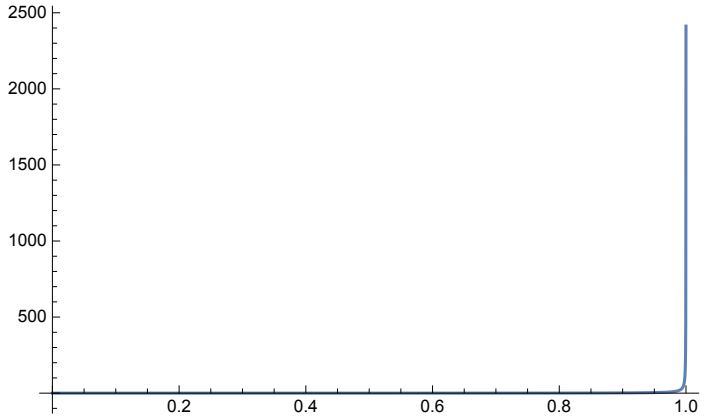
Out[98]=



Graf řešení $y_2(x)$

In[99]:=
```
v[[2]]
```

Out[99]=



Tabulka řešení $y_1(x)$

In[100]:=
```
MatrixForm[v[[3]]]
```

Out[100]//MatrixForm=

0.	0.
0.1	0.0000426505
0.2	0.000131616
0.3	0.000363544
0.4	0.000990347
0.5	0.00269286
0.6	0.00732095
0.7	0.0199147
0.8	0.0544226
0.9	0.154246
1.	1.55774

Tabulka řešení $y_2(x)$

In[101]:=
```
MatrixForm[v[[4]]]
```

Out[101]//MatrixForm=

0.	0.000362691
0.1	0.000559877
0.2	0.00136523
0.3	0.00365349
0.4	0.00991015
0.5	0.0269318
0.6	0.0732268
0.7	0.199477
0.8	0.550967
0.9	1.69999
1.	2413.22

$\alpha = 20.0$

Definice parametrů diferenciální rovnice

In[102]:=
```
α = 20.0;
```

Definice pravé strany diferenciální rovnice

In[103]:=
```
f[x_, y1_, y2_] = y2;
g[x_, y1_, y2_] = α Sinh[α y1];
```

Parametry programu Strelba2

In[105]:=
```
a = 0.0;
b = 1.0;
α1 = 1;
α2 = 1;
β1 = 0;
β2 = 0;
γ1 = 0;
γ2 = 1;
ϵ = 0.000001;
z0 = 0.000000050421;
m = 10;
Lx = Table[N[a + i (b - a) / m], {i, 0, m}];
```

In[117]:=
```
v = Strelba2[f, g, a, b, α1, α2 , β1, β2 , γ1 , γ2 , ϵ, z0, Lx];
```

```
i      z              s
0      5.0421×10^-8
```

NDSolve: At NumMath`DEStrelba`Private`x$1266 == 0.9441149517538657`, step size is effectively zero; singularity or stiff system suspected.

InterpolatingFunction: Input value {1.} lies outside the range of data in the interpolating function. Extrapolation will be used.

InterpolatingFunction: Input value {1.} lies outside the range of data in the interpolating function. Extrapolation will be used.

InterpolatingFunction: Input value {1.} lies outside the range of data in the interpolating function. Extrapolation will be used.

General: Further output of InterpolatingFunction::dmval will be suppressed during this calculation.

```
1      5.0421×10^-8      1.88411×10^-18
```

NDSolve: At NumMath`DEStrelba`Private`x$1266 == 0.9406887520790215`, step size is effectively zero; singularity or stiff system suspected.

Nepomohl ani hodně přesný nástřel, úloha je stiff - museli bychom zvolit jinou metodu pro řešení počáteční úlohy
(zde byla použita matoda Runge- Kuttova 4. řádu a ta není vhodná pro stiff úlohy)