# Applications solved by Levenberg-Marquardt Method in implementation of LMDER package by Garbow, Hillstrom and Moré

**Neculai Andrei**
*Research Institute for Informatics,*
*Center for Advanced Modeling and Optimization,*
*8-10, Averescu Avenue, Bucharest 1, Romania*
*E-mail: nandrei@ici.ro*

**Abstract.** *In this work we present the rezults of the Levenberg-Marquardt algorithm in implementation of LMDER package given by Garbow, Hillstrom and Moré for solving some real applications considered in the book: "Critica Raþiunii Algoritmilor de Optimizare fãrã Restricþii", chapter 14. The package is in public domain at the address: http://www.netlib.org/minpack/index.html.*

The purpose of LMDER is to minimize the sum of the squares of $m$ nonlinear functions in $n$ variables by a modification of the Levenberg-Marquardt algorithm given by Moré [1978].

**<u>Application Q1.</u> Circuit Design Problem**

```
     Circuit Design Problem. January 12, 2007
     Initial point and Functions values
        1     .7000000000000E+00     .9552504764826E+00
        2     .5000000000000E+00     .3041555430995E+01
        3     .9000000000000E+00    -.4166213167397E+01
        4     .1900000000000E+01    -.2118462145687E+01
        5     .8100000000000E+01     .5636125856655E+01
        6     .8100000000000E+01     .2231397917350E+02
        7     .5900000000000E+01     .2495943321819E+02
        8     .1000000000000E+01     .4218784331013E+02
        9     .1900000000000E+01    -.3200000000000E+00
  -------------------------------------------------------
     OK: iter=    22
     LMMDER package: Solution of the problem

        1     .9001161057629E+00     .1834670959801E+00
        2     .4467129934365E+00     .4551467965421E+00
        3     .1006753683178E+01    -.1461477278317E+00
        4     .1974001028530E+01    -.1119427379992E+00
        5     .8015978949713E+01    -.1984811967144E-01
        6     .7989079021508E+01    -.2129287326639E-02
        7     .5090375808511E+01     .5904981885450E-02
        8     .1002067813354E+01    -.7299838599522E-02
        9     .2032419024249E+01     .2438329626292E-01
     nfev=    26   njev=    21
```

**<u>Application Q2.</u> (Propan combustion in aer)**

```
     Propan Combustion in aer Problem. January 12, 2007
     Initial point and Functions values
        1     .1000000000000E+02     .1098500000000E+03
```

```
      2     .1000000000000E+02     .2095426765244E+03
      3     .5000000000000E-01    -.3487418805780E+00
      4     .5050000000000E+02     .5098517207139E+04
      5     .5000000000000E-01     .2659293083406E+04
-------------------------------------------------------
    OK: iter=    11
   LMMDER package: Solution of the problem

      1     .3114102265905E-02    -.1387778780781E-16
      2     .3459792453121E+02     .0000000000000E+00
      3     .6504177869658E-01     .5551115123126E-16
      4     .8593780505780E+00     .4218847493576E-14
      5     .3695185914805E-01     .2220446049250E-14
   nfev=    11   njev=    10
```

**<u>Application Q3.</u> (Stationar solution of a chemical reactor)**

```
   Solution of a chemical reactor. January 12, 2007
   Initial point and Functions values
      1     .1090000000000E+01    -.3516486400000E+02
      2     .1050000000000E+01    -.2403040000000E+00
      3     .3050000000000E+01     .3626946370000E+04
      4     .9900000000000E+00    -.1779923321000E+04
      5     .6050000000000E+01    -.1814712729000E+04
      6     .1090000000000E+01    -.7130000000000E+01
-------------------------------------------------------
    OK: iter=     6
   LMMDER package: Solution of the problem

      1     .9742436189517E+00     .2442490654175E-14
      2     .9828290793011E+00    -.2071122610979E-16
      3     .5151276209660E-01    -.1048643810675E-10
      4     .9356710687406E+00     .5240780032167E-11
      5     .9083976760406E-04     .5243194767246E-11
      6     .6423809149184E-01    -.2775557561563E-16
   nfev=     6   njev=     5
```

**<u>Application Q4.</u> (Robot Cinematics Problem)**

```
   Robot Cinematics Problem. January 12, 2007
   Initial point and Functions values
      1     .1640000000000E+00     .2682369040000E-02
      2    -.9800000000000E+00    -.9818048000000E-02
      3    -.9400000000000E+00     .9954282000000E-01
      4    -.3200000000000E+00     .1758800000000E-02
      5    -.9900000000000E+00    -.1270400000000E-01
      6    -.5000000000000E-01    -.1400000000000E-01
      7     .4100000000000E+00    -.1740000000000E-01
      8    -.9100000000000E+00    -.3800000000000E-02
-------------------------------------------------------
    OK: iter=     5
   LMMDER package: Solution of the problem

      1     .1644316658543E+00     .0000000000000E+00
      2    -.9863884768510E+00     .0000000000000E+00
      3    -.9470636915416E+00     .2602085213965E-17
      4    -.3210457353143E+00     .0000000000000E+00
      5    -.9982331646551E+00    -.1110223024625E-15
      6     .5941842292353E-01     .2220446049250E-15
      7     .4110331567472E+00     .0000000000000E+00
      8    -.9116203947118E+00     .0000000000000E+00
   nfev=     5   njev=     4
```

**<u>Application Q5.</u> (Solid Fuel Ignition Problem)**

```
    Solid Fuel Ignition Problem. January 12, 2007
-------------------------------------------------------
     OK: iter=     5
    LMMDER package: Solution of the problem

    nfev=     5   njev=     4
```

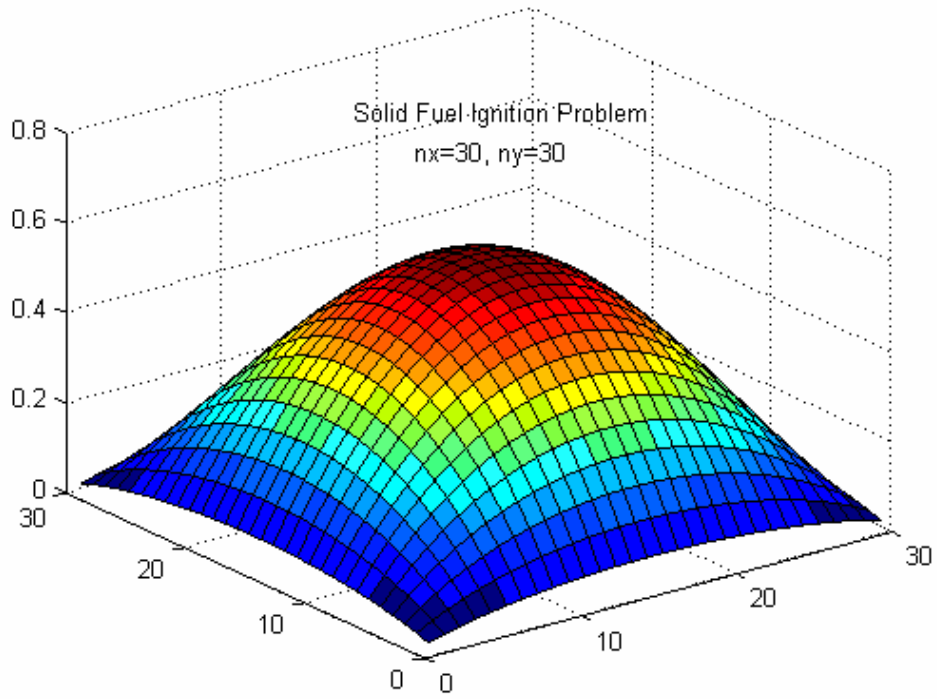


**Fig. Q5.** Solid fuel ignition. Bratu Problem.

**<u>Application Q6.</u> (Flow in a Driven Cavity Problem)**

For: **nx = 30, ny = 30, R=200** we get:

```
    Flow in a Driven Cavity Problem. January 12, 2007
-------------------------------------------------------
     OK: iter=     6
    LMMDER package: Solution of the problem

    nfev=     6   njev=     5
```

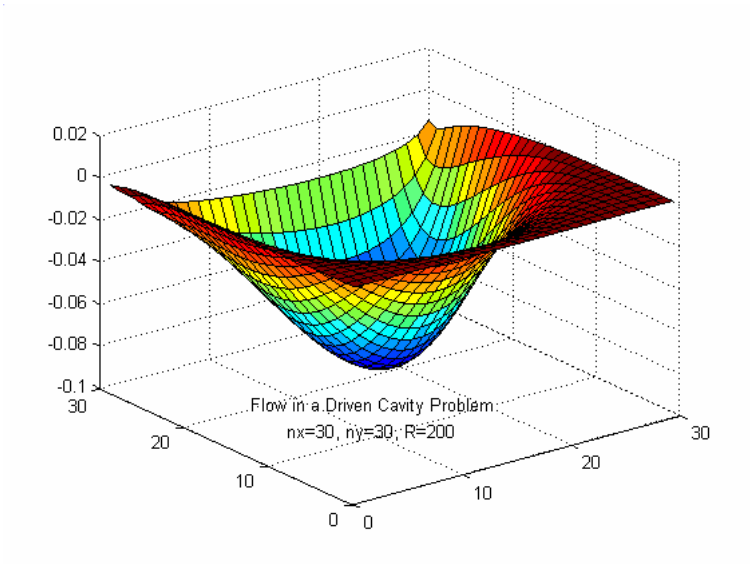


**Fig. Q6a.** Solution of the problem. R=200.

For: **nx = 30, ny = 30, R=400**, we get:

```
     Flow in a Driven Cavity Problem. January 12, 2007
  -------------------------------------------------------
      OK: iter=     7
     LMMDER package: Solution of the problem

     nfev=     7   njev=     6
```

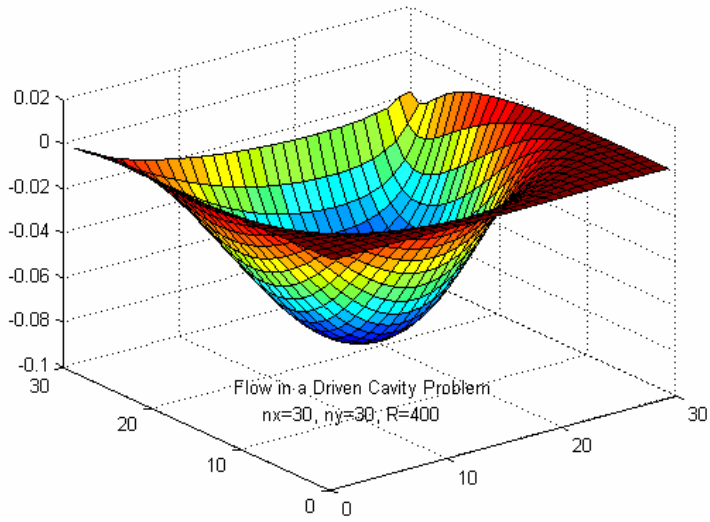


**Fig. Q6b.** Solution of the problem. R=400.

For: **nx = 30, ny = 30, R=1000** we get:

```
Flow in a Driven Cavity Problem. January 12, 2007
  -------------------------------------------------------
      OK: iter=    11
     LMMDER package: Solution of the problem

     nfev=    13   njev=    10
```

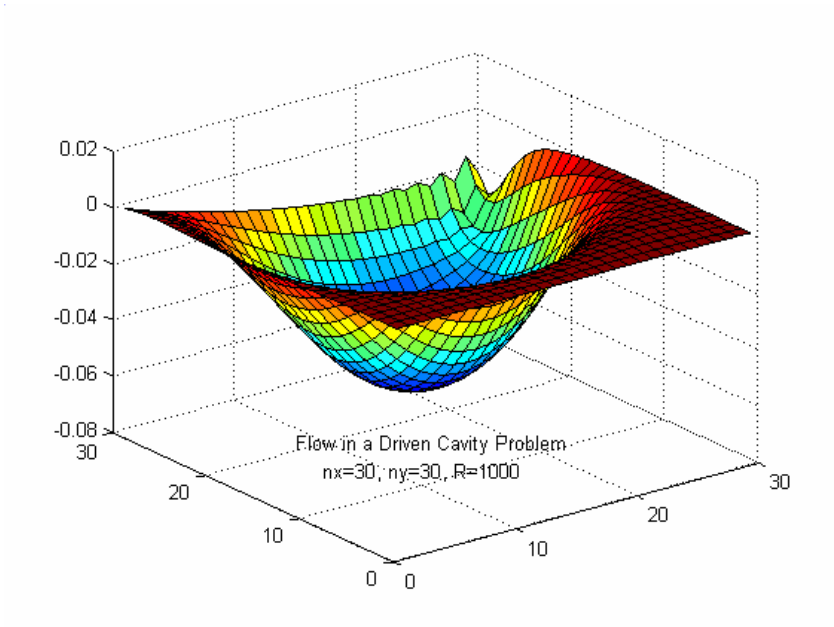


**Fig. Q6c.** Solution of the problem. R=1000.

For: **nx = 40, ny = 40, R=200** we get:

```
Flow in a Driven Cavity Problem. January 15, 2007
  -----------------------------------------------------
      OK: iter=     6
     LMMDER package: Solution of the problem

     nfev=     6   njev=     5
```

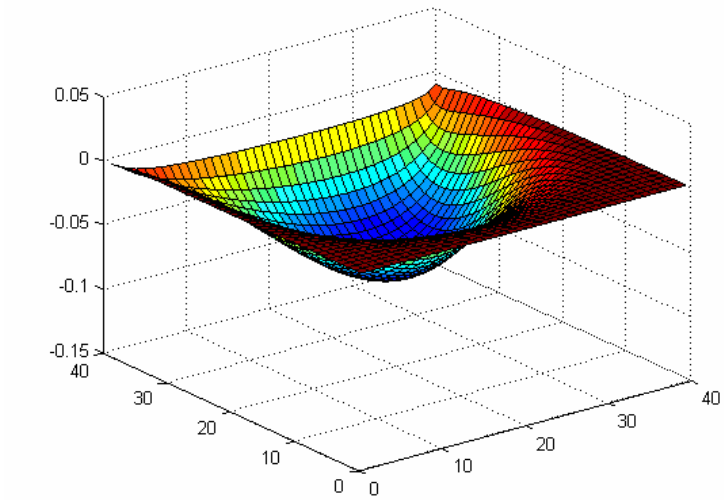


**Fig. Q6d.** Solution of the problem. R=200.

For: **nx = 40, ny = 40, R=400** we get:

```
Flow in a Driven Cavity Problem. January 15, 2007
  -----------------------------------------------------
      OK: iter=     7
     LMMDER package: Solution of the problem

     nfev=     7   njev=     6
```

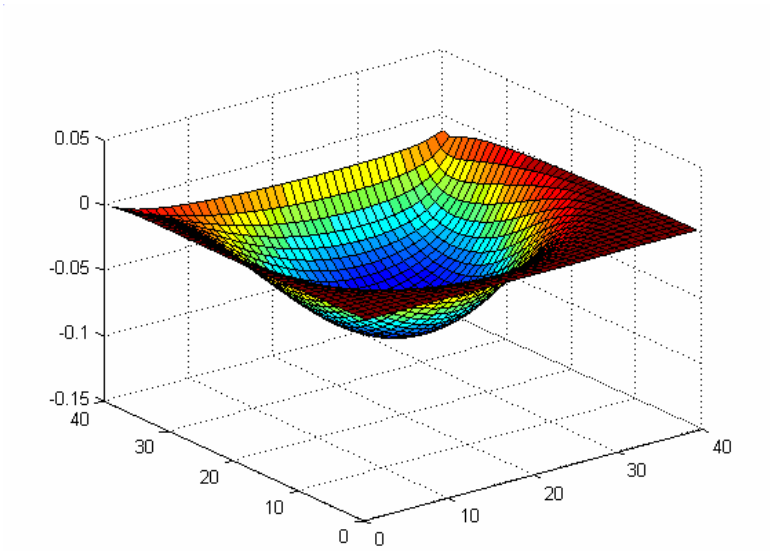


**Fig. Q6e.** Solution of the problem. R=400.

For: **nx = 40, ny = 40, R=1000** we get:

```
Flow in a Driven Cavity Problem. January 15, 2007
  -------------------------------------------------------
      OK: iter=    11
     LMMDER package: Solution of the problem

     nfev=    11   njev=    10
```

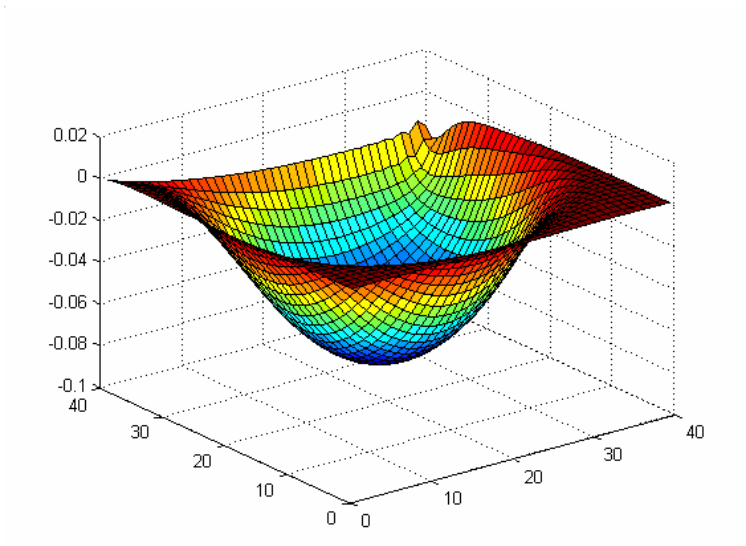


**Fig. Q6f.** Solution of the problem. R=1000.

For **nx = 50, ny = 50, R=200** we get:

```
Flow in a Driven Cavity Problem. January 15, 2007
  -------------------------------------------------------
      OK: iter=     6
     LMMDER package: Solution of the problem

     nfev=     6   njev=     5
```

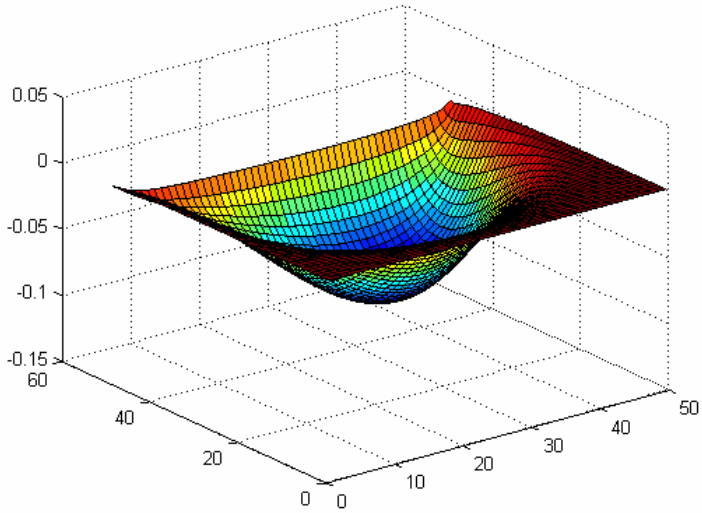


**Fig. Q6g.** Solution of the problem. R=200.

For **nx = 50, ny = 50, R=400** we get:

```
Flow in a Driven Cavity Problem. January 15, 2007
  -----------------------------------------------------
      OK: iter=     7
     LMMDER package: Solution of the problem

     nfev=     7   njev=     6
```

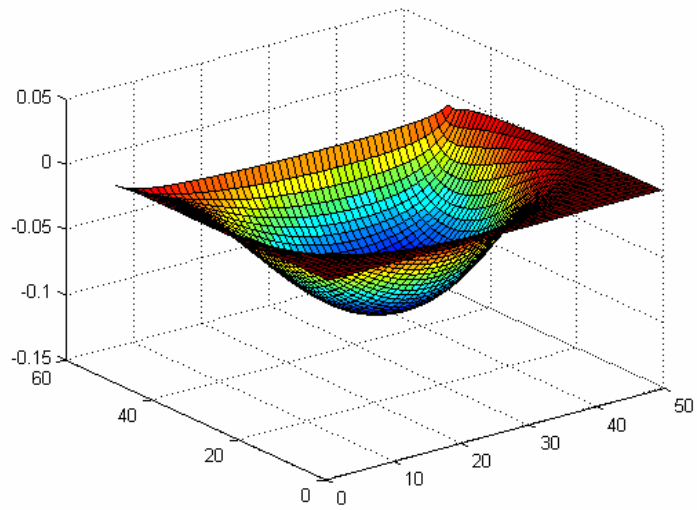


**Fig. Q6h.** Solution of the problem. R=400.

For **nx = 50, ny = 50, R=1000** we get:

```
Flow in a Driven Cavity Problem. January 15, 2007
  -----------------------------------------------------
      OK: iter=     8
     LMMDER package: Solution of the problem

     nfev=     8   njev=     7
```

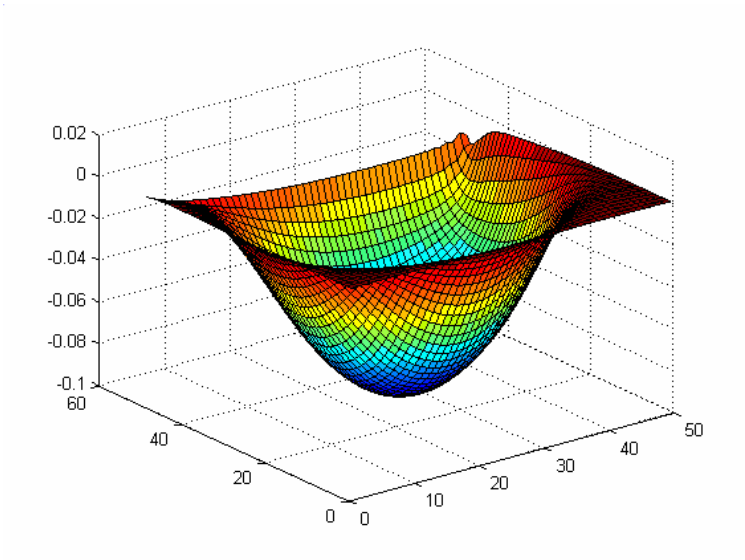


**Fig. Q6i.** Solution of the problem. R=1000.

**January 15, 2007**