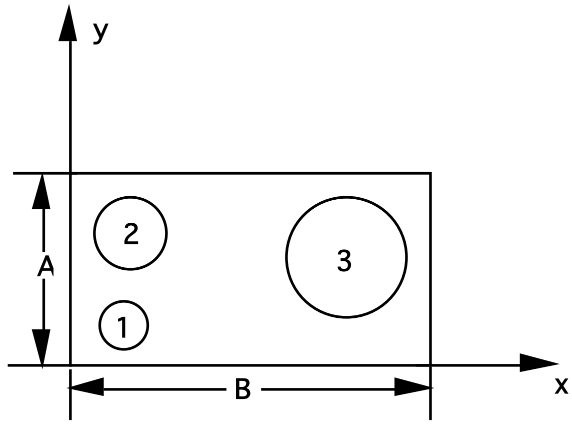
06-606 **Assignment #6** **Fall, 2011**

Due: 11/18/11

1. Consider the nonconvex, constrained NLP:



Min $(A + B)$

$$\begin{cases} x_1,\ y_1 \geq R_1 & x_1 \leq B - R_1,\ y_1 \leq A - R_1 \\ x_2,\ y_2 \geq R_2 & x_2 \leq B - R_2,\ y_2 \leq A - R_2 \\ x_3,\ y_3 \geq R_3 & x_3 \leq B - R_3,\ y_3 \leq A - R_3 \end{cases}$$

$$\text{no overlaps} \begin{cases} (x_1 - x_2)^2 + (y_1 - y_2)^2 \geq (R_1 + R_2)^2 \\ (x_1 - x_3)^2 + (y_1 - y_3)^2 \geq (R_1 + R_3)^2 \\ (x_2 - x_3)^2 + (y_2 - y_3)^2 \geq (R_2 + R_3)^2 \end{cases}$$

$$x_1, x_2, x_3, y_1, y_2, y_3,\ A, B \geq 0$$

Write the Kuhn Tucker conditions for this problem.

a) Show that this problem is nonconvex

b) What can you say about the optimal active set of inequalities for this problem?

c) How does the system of Kuhn Tucker conditions lead to multiple NLP solutions?

2. Consider the NLP:

$$\begin{aligned} &\text{Min } x_2 \\ \text{s.t.} \quad & x_1 - x_2^2 + 1 \le 0 \\ & -x_1 - x_2^2 + 1 \le 0 \end{aligned}$$

a) Sketch the feasible region for this problem

b) Using GAMS, what happens if $x_1 = x_2 = 0$ is chosen as a starting point and SQP (SNOPT) or reduced gradient methods (CONOPT) are applied?

3. While searching for the minimum of

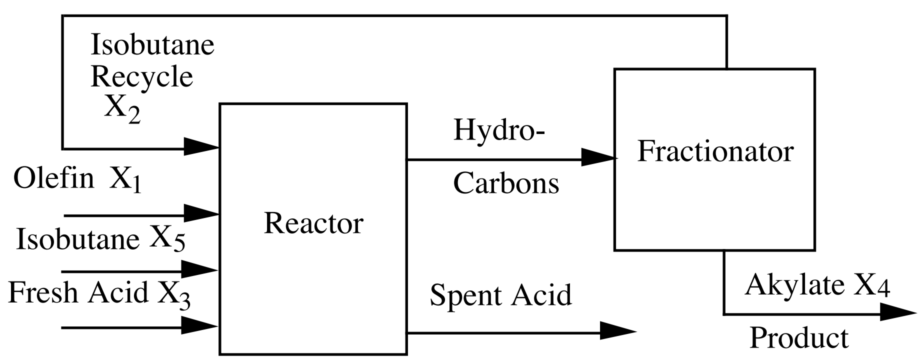
$$f(x) = [x_1^2 + (x_2+ 1)^2][x_1^2 + (x_2 - 1)^2]$$

we terminate the following points

a) $x^{(1)} = [0,0]^T$
b) $x^{(2)} = [0,1]^T$
c) $x^{(3)} = [0,-1]^T$
d) $x^{(4)} = [1,1]^T$

Classify each point.

4. Consider the alkylation process shown below from Bracken & McCormick (1968)



X_1 = Olefin feed (barrels per day)
X_2 = Isobutane recycle (barrels per day)
X_3 = Acid addition rate (1000s pounds/day)
X_4 = Alkylate yield (barrels/day)
X_5 = Isobutane input (barrels per day)
X_6 = Acid strength (weight percent)
X_7 = Motor octane number alkylate
X_8 = External isobutane-to-olefin ratio
X_9 = Acid dilution factor
X_{10} = F-4 performance no. of alkylate

The alkylation is derived from simple mass balance relationships and regression equations determined from operating data. The first four relationships represent characteristics of the alkylation reactor and are given empirically.

The alkylate field yield, X4, is a function of both the olefin feed, X1, and the external isobutane to olefin ratio, X8. The following relation is developed from a nonlinear regression for temperature between 80 and 90 degrees F and acid strength between 85 and 93 weight percent:

$$X4 = X1*(1.12 + .12167*X8 - 0.0067*X8**2)$$

The motor octane number of the alkylate, X7, is a function of X8 and the acid strength, X6. The nonlinear regression under the same conditions as for X4 yields:

$$X7 = 86.35 + 1.098*X8 - 0.038*X8**2 + 0.325*(X6-89.)$$

The acid dilution factor, X9, can be expressed as a linear function of the F-4 performance number, X10 and is given by:

$$X9 = 35.82 - 0.222*X10$$

Also, X10 is expressed as a linear function of the motor octane number, X7.

$$X10 = 3*X7 - 133$$

The remaining three constrants represent exact definitions for the remaining variables. The external isobutane to olefin ratio is given by:

$$X8 = (X2 + X5)/X1$$

To prevent potential zero divides it is rewritten as:

$$X8*X1 = X2 + X5$$

The isobutane feed, X5, is determined by a volume balance on the system. Here olefins are related to alkylated product and there is a constant 22% volume shrinkage, thus giving X4 = X1 + X5 - 0.22*X4 or:

$$X5 = 1.22*X4 - X1$$

Finally, the acid dilution strength (X6) is related to the acid addition rate (X3), the acid dilution factor (X9) and the alkylate yield (X4) by the equation, 1000*X3 + X4*X6*X9(98 - X6). Again, we reformulate this equation to eliminate the division and obtain:

$$X6*(Xr*X9+1000*X3) = 98000*X3$$

The objective function is a straightforward profit calculation based on the following data:

- Alkylate product value = \$0.063/octane-barrel
- Olefin feed cost = \$5.04/barrel
- Isobutane feed cost = \$3.36/barrel
- Isobutane recycle cost = \$0.035/barrel
- Acid addition cost = \$10.00/barrel

This yields the objective function to be maximized is therefore the profit (\$/day)

$$OBJ = 0.063*X4*X7 - 5.04*X1 - 0.035*X2 - 10*X3 - 3.36*X5$$

The following exercises are based on the description in Liebman et al (1984).

a) Set up this NLP problem and solve.

b) The regression equations presented in section 2 are based on operating data and are only approximations and it is assumed that equally accurate expressions actually lie in a band around these expressions. Therefore, in order to consider the effect of this band, Liebman et al (1984) suggested a relaxation of the regression variables. Replace the variables X4, X7, X9 and X10 with RX4, RX7, RX9 and RX10 in the regression equations (only) and impose the constraints:

$$0.99*X4 \leq RX4 \leq 1.01*X4$$
$$0.99*X7 \leq RX7 \leq 1.01*X7$$
$$0.99*X9 \leq RX9 \leq 1.01*X9$$
$$0.9*X10 \leq RX10 \leq 1.11*X10$$

to allow for the relaxation. Resolve with this fomulation. How would you interpret these results?

Solution - Homework 3

1. Consider NLP

$$\text{Min } (A+B)$$
$$\text{s.t.} \quad x_i, y_i \geq R_i \qquad i = 1, 3$$
$$x_i \leq B - R_i$$
$$y_i \leq A - R_i \leq 0$$
$$(x_i - x_j)^2 + (y_i - y_j)^2 \geq (R_i + R_j)^2$$
$$\forall i \neq j$$

KKT conditions

- $x_i, y_i \geq 0$ are redundant and are always inactive
- for x_i & y_i : $\mu_{Bi}(x_i - B + R_i) = 0$

$\mu_{Ai}(y_i - A + R_i) = 0$, $\mu_{xi}(R_i - x_i) = \mu_{yi}(R_i - y_i) = 0$

i) $-2(x_1 - x_2)\mu_{12} - 2(x_1 - x_3)\mu_{13} - \mu_{x1} + \mu_{B1} = 0$

$-2(x_2 - x_1)\mu_{12} - 2(x_2 - x_3)\mu_{23} - \mu_{x2} + \mu_{B2} = 0$

$-2(x_3 - x_1)\mu_{13} - 2(x_3 - x_2)\mu_{23} - \mu_{x3} + \mu_{B3} = 0$

ii) $-2(y_1 - y_2)\mu_{12} - 2(y_1 - y_3)\mu_{13} - \mu_{y1} + \mu_{A1} = 0$

$-2(y_2 - y_1)\mu_{12} - 2(y_2 - y_3)\mu_{23} - \mu_{y2} + \mu_{A2} = 0$

$-2(y_3 - y_1)\mu_{13} - 2(y_3 - y_2)\mu_{23} - \mu_{y3} + \mu_{A3} = 0$

- for A & B

iii) $1 - (\mu_{A1} + \mu_{A2} + \mu_{A3}) = 0$

$1 - (\mu_{B1} + \mu_{B2} + \mu_{B3}) = 0$

Also, $\mu_{ij}((x_i - x_j)^2 + (y_i - y_j)^2 - (R_i + R_j)^2) = 0$

a) Nonconvexity - for quadratic constraints

$$g(x,y) = -(x_i^2 + x_j^2 - 2x_i x_j) - (y_i^2 + y_j^2 - 2y_i y_j) - (R_i^2 + R_j^2) \leq 0$$

$$\nabla^2 g = \begin{bmatrix} -2 & -2 & & \\ -2 & -2 & & \\ & & -2 & -2 \\ & & -2 & -2 \end{bmatrix}$$

eigenvalues of $\begin{bmatrix} -2 & -2 \\ -2 & -2 \end{bmatrix}$ are

$$(-2-\lambda)^2 - 4 = 4\lambda + \lambda^2 = 0$$

$$\lambda = 0, -4$$

This matrix is negative semidefinite, hence not convex.

b) from iii) we know at least one circle i must touch upper bounds A and B. (i.e. $x_i = B - R_i$, $y_i = A - R_i$)

by adding up i) then

$$\mu_{x1} + \mu_{x2} + \mu_{x3} = \mu_{B1} + \mu_{B2} + \mu_{B3} = 1$$

and at least one circle must touch $x = 0$ (i.e. $x_i = R_i$)

by adding up ii) then

$$\mu_{y1} + \mu_{y2} + \mu_{y3} = \mu_{A1} + \mu_{A2} + \mu_{A3} = 1$$

and at least one circle must touch $y = 0$ (i.e. $y_i = R_i$)

if $2R_i \lneq A$, $2R_i \lneq B$, $\mu_{xi}\mu_{Bi} = 0$, $\mu_{yi}\mu_{Ai} = 0$

then if $\mu_{xi} > 0$ or $\mu_{Bi} > 0$, from

i) e.g.

$$2(x_1 - x_2)\overset{\geq 0}{\mu_{12}} + 2(x_1 - x_3)\overset{\geq 0}{\mu_{13}} = \overset{\geq 0}{\mu_{B1}} - \mu_{x1}$$

and 1 & 2 or 2 & 3 must touch (or both).

if $\mu_{B1} > 0$ $\quad x_1 > x_2$ or $x_1 > x_3$

if $\mu_{x1} > 0$ $\quad x_2 > x_1$ or $x_3 > x_1$

similar argument can be made for

y_i, μ_{Ai}, μ_{yi}

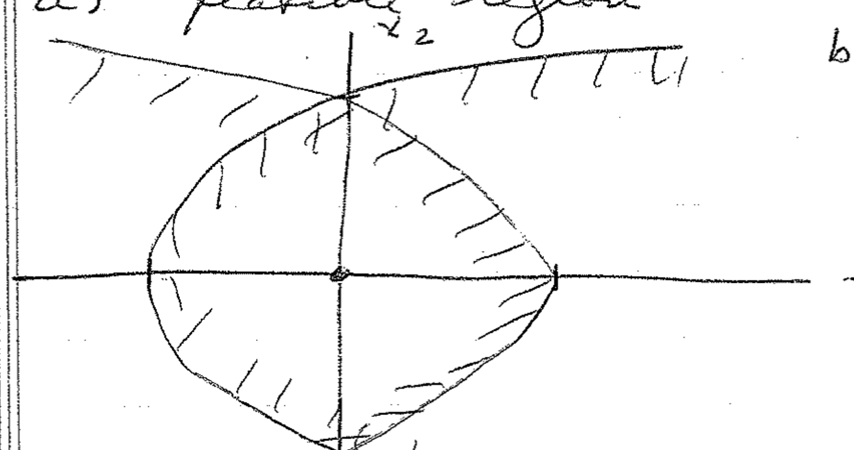
c) The problem has nonunique solutions. For example, if we interchange $x_i \leftrightarrow y_i$ and $A \leftrightarrow B$, the KKT conditions are still satisfied.

2. Min x_2

s.t. $x_1 - x_2^2 + 1 \leq 0$

$-x_1 - x_2^2 + 1 \leq 0$

a) feasible region



b) Both SQP and GRG start by linearizing about $x^0 = 0$. This linearization $\Delta x_1 \leq -1, \Delta x_1 \geq 1$ is inconsistent and both methods fail unless some "trick" is applied.

4a

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02/04/04                                                          alky.ls

^LGAMS Rev 130  Windows NT/95/98                  02/04/04 16:05:13  PAGE
    1
ALKYLATION PROBLEM FROM GINO USER'S MANUAL


   4
   5  OPTION LIMROW=0;
   6  OPTION LIMCOL=0;
   7
   8  POSITIVE VARIABLES X1,X2,X3,X4,X5,X6,X7,X8,X9,X10;
   9
  10  VARIABLE OBJ;
  11
  12  EQUATIONS E1,E2,E3,E4,E5,E6,E7,E8;
  13
  14  E1..X4=E=X1*(1.12+.12167*X8-0.0067*X8**2);
  15  E2..X7=E=86.35+1.098*X8-0.038*X8**2+0.325*(X6-89.);
  16  E3..X9=E=35.82-0.222*X10;
  17  E4..X10=E=3*X7-133;
  18  E5..X8*X1=E=X2+X5;
  19  E6..X5=E=1.22*X4-X1;
  20  E7..X6*(X4*X9+1000*X3)=E=98000*X3;
  21
  22  E8.. OBJ =E= 0.063*X4*X7-5.04*X1-0.035*X2-10*X3-3.36*X5;
  23
  24  X1.LO = 0.;
  25  X1.UP = 2000.;
  26  X2.LO = 0.;
  27  X2.UP = 16000.;
  28  X3.LO = 0.;
  29  X3.UP = 120.;
  30  X4.LO = 0.;
  31  X4.UP = 5000.;
  32  X5.LO = 0.;
  33  X5.UP = 2000.;
  34  X6.LO = 85.;
  35  X6.UP = 93.;
  36  X7.LO = 90;
  37  X7.UP = 95;
  38  X8.LO = 3.;
  39  X8.UP = 12.;
  40  X9.LO = 1.2;
  41  X9.UP = 4.;
  42  X10.LO = 145.;
  43  X10.UP = 162.;
  44
  45  X1.L =1745;
  46  X2.L =12000;
  47  X3.L =110;
  48  X4.L =3048;
  49  X5.L =1974;
  50  X6.L =89.2;
  51  X7.L =92.8;
  52  X8.L =8;
  53  X9.L =3.6;
  54  X10.L =145;
  55
  56  MODEL ALKY/ALL/;
  57
  58  SOLVE ALKY USING NLP MAXIMIZING OBJ;
^LGAMS Rev 130  Windows NT/95/98                  02/04/04 16:05:13  PAGE
    2
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02/04/04                                                          alky.ls

ALKYLATION PROBLEM FROM GINO USER'S MANUAL



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    3
ALKYLATION PROBLEM FROM GINO USER'S MANUAL
Model Statistics    SOLVE ALKY USING NLP FROM LINE 58



MODEL STATISTICS

BLOCKS OF EQUATIONS          8     SINGLE EQUATIONS          8
BLOCKS OF VARIABLES         11     SINGLE VARIABLES         11
NON ZERO ELEMENTS           28     NON LINEAR N-Z           11
DERIVATIVE POOL              7     CONSTANT POOL            16
CODE LENGTH                132


GENERATION TIME      =        0.010 SECONDS     2.0 Mb      WIN205-130


EXECUTION TIME       =        0.010 SECONDS     2.0 Mb      WIN205-130
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    4
ALKYLATION PROBLEM FROM GINO USER'S MANUAL


               S O L V E      S U M M A R Y

     MODEL   ALKY                OBJECTIVE  OBJ
     TYPE    NLP                 DIRECTION  MAXIMIZE
     SOLVER  CONOPT              FROM LINE  58

**** SOLVER STATUS     1 NORMAL COMPLETION
**** MODEL STATUS      2 LOCALLY OPTIMAL
**** OBJECTIVE VALUE              911.1376

 RESOURCE USAGE, LIMIT          0.020      1000.000
 ITERATION COUNT, LIMIT        20         10000
 EVALUATION ERRORS              0             0


   C O N O P T 2   Windows NT/95/98  version 2.071H-009-045
   Copyright (C)   ARKI Consulting and Development A/S
                   Bagsvaerdvej 246 A
                   DK-2880 Bagsvaerd, Denmark

 Using default control program.


 ** Optimal solution. Reduced gradient less than tolerance.


 CONOPT time Total                          0.008 seconds
   of which: Function evaluations           0.000 =  0.0%
```

```
          Derivative evaluations      0.000 =  0.0%

 Work length =     0.05 Mbytes
    Estimate =     0.05 Mbytes
    Max used =     0.04 Mbytes

                        LOWER     LEVEL     UPPER    MARGINAL

---- EQU E1               .         .         .         1.469
---- EQU E2             57.425    57.425    57.425   436.592
---- EQU E3             35.820    35.820    35.820  -351.315
---- EQU E4           -133.000  -133.000  -133.000    77.992
---- EQU E5               .         .         .         0.082
---- EQU E6               .         .         .        -3.354
---- EQU E7               .         .         .         0.001
---- EQU E8               .         .         .         1.000

                        LOWER     LEVEL     UPPER    MARGINAL

---- VAR X1               .     1923.693  2000.000      .
---- VAR X2               .    16000.000 16000.000     0.047
---- VAR X3               .      106.842   120.000      EPS
---- VAR X4               .     3216.142  5000.000      .
---- VAR X5               .     2000.000  2000.000     0.077
---- VAR X6             85.000    89.781    93.000      .
---- VAR X7             90.000    93.551    95.000      .
---- VAR X8              3.000     9.357    12.000      .
^LGAMS Rev 130  Windows NT/95/98                    02/04/04 16:05:13   PAGE
     5
ALKYLATION PROBLEM FROM GINO USER'S MANUAL


                        LOWER     LEVEL     UPPER    MARGINAL

---- VAR X9              1.200     3.041     4.000      .
---- VAR X10           145.000   147.652   162.000      .
---- VAR OBJ             -INF    911.138     +INF       .


**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                             0  UNBOUNDED
                             0     ERRORS


EXECUTION TIME       =        0.000 SECONDS      0.8 Mb      WIN205-130


USER: Ignacio E. Grossmann                          G010116:1316AE-WIN
      Carnegie Mellon University, Dept. of Chemical Engineering  DC2272

**** FILE SUMMARY

INPUT      C:\DOCUMENTS AND SETTINGS\LORENZ BIEGLER\DESKTOP\06-720\ALKY.GMS
OUTPUT     C:\DOCUMENTS AND SETTINGS\LORENZ BIEGLER\DESKTOP\ALKY.LST
```

(99)

4b


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^LGAMS Rev 130  Windows NT/95/98                       02/04/04 16:39:22  PAGE
    1
ALKYLATION PROBLEM FROM GINO USER'S MANUAL


   4
   5  OPTION LIMROW=0;
   6  OPTION LIMCOL=0;
   7
   8  POSITIVE VARIABLES X1,X2,X3,X4,X5,X6,X7,X8,X9,X10, RX4, RX7, RX9, RX10
;
   9
  10  VARIABLE OBJ;
  11
  12  EQUATIONS E1,E2,E3,E4,E5,E6,E7,E8, E9, E10, E11, E12,
  13  E13, E14, E15, E16;
  14
  15  E1..RX4=E=X1*(1.12+.12167*X8-0.0067*X8**2);
  16  E2..RX7=E=86.35+1.098*X8-0.038*X8**2+0.325*(X6-89.);
  17  E3..RX9=E=35.82-0.222*RX10;
  18  E4..RX10=E=3*RX7-133;
  19  E5..X8*X1=E=X2+X5;
  20  E6..X5=E=1.22*RX4-X1;
  21  E7..X6*(RX4*RX9+1000*X3)=E=98000*X3;
  22
  23  E8.. OBJ =E= 0.063*X4*X7-5.04*X1-0.035*X2-10*X3-3.36*X5;
  24
  25  E9.. RX4 =L= 1.01*X4;
  26  E10.. RX4 =G= 0.99*X4;
  27  E11.. RX7 =L= 1.01*X7;
  28  E12.. RX7 =G= 0.99*X7;
  29  E13.. RX9 =L= 1.01*X9;
  30  E14.. RX9 =G= 0.99*X9;
  31  E15.. RX10 =L= 1.11*X10;
  32  E16.. RX10 =G= 0.9*X10;
  33
  34  X1.LO = 0.;
  35  X1.UP = 2000.;
  36  X2.LO = 0.;
  37  X2.UP = 16000.;
  38  X3.LO = 0.;
  39  X3.UP = 120.;
  40  X4.LO = 0.;
  41  X4.UP = 5000.;
  42  X5.LO = 0.;
  43  X5.UP = 2000.;
  44  X6.LO = 85.;
  45  X6.UP = 93.;
  46  X7.LO = 90;
  47  X7.UP = 95;
  48  X8.LO = 3.;
  49  X8.UP = 12.;
  50  X9.LO = 1.2;
  51  X9.UP = 4.;
  52  X10.LO = 145.;
  53  X10.UP = 162.;
  54
  55  X1.L =1745;
  56  X2.L =12000;
  57  X3.L =110;
  58  X4.L =3048;
^LGAMS Rev 130  Windows NT/95/98                       02/04/04 16:39:22  PAGE
```



```
    2
ALKYLATION PROBLEM FROM GINO USER'S MANUAL


  59  X5.L =1974;
  60  X6.L =89.2;
  61  X7.L =92.8;
  62  X8.L =8;
  63  X9.L =3.6;
  64  X10.L =145;
  65
  66  RX4.L =3048;
  67  RX7.L =92.8;
  68  RX9.L =3.6;
  69  RX10.L =145;
  70
  71  MODEL ALKY2/E1,E2,E3,E4,E5,E6,E7,E8,E9,E10,E11,E12,E13,E14,E15,E16/
  72
  73  SOLVE ALKY2 USING NLP MAXIMIZING OBJ;


COMPILATION TIME     =        0.000 SECONDS      0.8 Mb      WIN205-130
^LGAMS Rev 130  Windows NT/95/98                       02/04/04 16:39:22  PAGE
    3
ALKYLATION PROBLEM FROM GINO USER'S MANUAL
Model Statistics    SOLVE ALKY2 USING NLP FROM LINE 73



MODEL STATISTICS

BLOCKS OF EQUATIONS       16     SINGLE EQUATIONS        16
BLOCKS OF VARIABLES       15     SINGLE VARIABLES        15
NON ZERO ELEMENTS         44     NON LINEAR N-Z          11
DERIVATIVE POOL            7     CONSTANT POOL           16
CODE LENGTH              132


GENERATION TIME      =        0.010 SECONDS      2.0 Mb      WIN205-130


EXECUTION TIME       =        0.010 SECONDS      2.0 Mb      WIN205-130
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    4
ALKYLATION PROBLEM FROM GINO USER'S MANUAL


               S O L V E      S U M M A R Y

     MODEL   ALKY2                 OBJECTIVE  OBJ
     TYPE    NLP                   DIRECTION  MAXIMIZE
     SOLVER  CONOPT                FROM LINE  73

**** SOLVER STATUS     1 NORMAL COMPLETION
**** MODEL STATUS      2 LOCALLY OPTIMAL
**** OBJECTIVE VALUE             1296.0619

 RESOURCE USAGE, LIMIT          0.008      1000.000
 ITERATION COUNT, LIMIT        13          10000
 EVALUATION ERRORS              0              0
```

```
EVALUATION ERRORS              0              0

   C O N O P T 2   Windows NT/95/98  version 2.071H-009-045
   Copyright (C)   ARKI Consulting and Development A/S
                   Bagsvaerdvej 246 A
                   DK-2880 Bagsvaerd, Denmark

Using default control program.

** Optimal solution. Reduced gradient less than tolerance.

CONOPT time Total                        0.000 seconds
  of which: Function evaluations         0.000 =  0.0%
            Derivative evaluations       0.000 =  0.0%

Work length =    0.05 Mbytes
   Estimate =    0.05 Mbytes
   Max used =    0.04 Mbytes
```

	LOWER	LEVEL	UPPER	MARGINAL
---- EQU E1	.	.	.	1.373
---- EQU E2	57.425	57.425	57.425	443.589
---- EQU E3	35.820	35.820	35.820	-355.643
---- EQU E4	-133.000	-133.000	-133.000	78.953
---- EQU E5	.	.	.	0.084
---- EQU E6	.	.	.	-3.531
---- EQU E7	.	.	.	0.001
---- EQU E8	.	.	.	1.000
---- EQU E9	-INF	-64.973	.	.
---- EQU E10	.	.	+INF	-6.015
---- EQU E11	-INF	-1.891	.	.
---- EQU E12	.	.	+INF	-206.731
---- EQU E13	-INF	-0.028	.	.
---- EQU E14	.	0.032	+INF	EPS
---- EQU E15	-INF	-13.208	.	.
---- EQU E16	.	17.242	+INF	.

```
^LGAMS Rev 130  Windows NT/95/98                    02/04/04 16:39:22  PAGE
    5
ALKYLATION PROBLEM FROM GINO USER'S MANUAL
```

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR X1	.	1923.693	2000.000	.
---- VAR X2	.	16000.000	16000.000	0.049
---- VAR X3	.	107.452	120.000	.
---- VAR X4	.	3248.628	5000.000	.
---- VAR X5	.	2000.000	2000.000	0.255
---- VAR X6	85.000	89.873	93.000	.
---- VAR X7	90.000	94.526	95.000	EPS
---- VAR X8	3.000	9.357	12.000	.
---- VAR X9	1.200	3.019	4.000	.
---- VAR X10	145.000	145.000	162.000	EPS
---- VAR RX4	.	3216.142	+INF	.
---- VAR RX7	.	93.581	+INF	.
---- VAR RX9	.	3.021	+INF	.
---- VAR RX10	.	147.742	+INF	.


```
---- VAR OBJ            -INF   1296.062     +INF       .

**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                             0  UNBOUNDED
                             0     ERRORS

EXECUTION TIME       =       0.000 SECONDS      0.8 Mb      WIN205-130

USER: Ignacio E. Grossmann                               G010116:1316AE-WIN
      Carnegie Mellon University, Dept. of Chemical Engineering  DC2272

**** FILE SUMMARY

INPUT      C:\DOCUMENTS AND SETTINGS\LORENZ BIEGLER\DESKTOP\06-720\ALKYB.GMS
OUTPUT     C:\DOCUMENTS AND SETTINGS\LORENZ BIEGLER\DESKTOP\ALKYB.LST
```