MAE598/494 Design Optimization Homework 1

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Problem 1.a)

Use initial point: x0 = (2, 2, 2, 2, 2) to solve:

minimize:
$(x1 - x2)^2 + (x2 + x3 - 2)^2 + (x4 - 1)^2 + (x5 - 1)^2$

subject to:
$x1 + 3x2 = 0$
$x3 + x4 - 2x5 = 0$
$x2 - x5 = 0$
$-10 <= xi <= 10, i = 1, ..., 5$

(Refer next page for solution using the Excel Solver and Matlab's *fmincon* solver.)

Microsoft Excel 15.0 Answer Report
Worksheet: [aviprada_hw1.xlsx]Sheet1
Report Created: 18/01/2016 8:06:10 PM
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine

Engine: GRG Nonlinear
Solution Time: 0.062 Seconds.
Iterations: 1 Subproblems: 0

Solver Options

Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Convergence 0.0001, Population Size 100, Random Seed 0, Derivatives Forward, Require Bounds
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%

Objective Cell (Min)

Cell	Name	Original Value	Final Value
$C$7	(x1 - x2)^2 + (x2 + x3 - 2)^2 + (x4 - 1)^2 + (x5 - 1)^2	6.00000	4.09302

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$C$1	x1 =	2.00000	-0.76744	Contin
$C$2	x2 =	2.00000	0.25581	Contin
$C$3	x3 =	2.00000	0.62791	Contin
$C$4	x4 =	2.00000	-0.11628	Contin
$C$5	x5 =	2.00000	0.25581	Contin

Constraints

Cell	Name	Cell Value	Formula	Status
$C$10	x3 + x4 - 2*x5 = 0	0.00000	$C$10=$E$10	Binding
$C$11	x2 - x5 = 0	0.00000	$C$11=$E$11	Binding
$C$12	x1 >= -10, x1 <= 10	-0.76744	$C$12<=$G$12	Not Binding
$C$12	x1 >= -10, x1 <= 10	-0.76744	$C$12>=$E$12	Not Binding
$C$13	x2 >= -10, x2 <= 10	0.25581	$C$13<=$G$13	Not Binding
$C$13	x2 >= -10, x2 <= 10	0.25581	$C$13>=$E$13	Not Binding
$C$14	x3 >= -10, x3 <= 10	0.62791	$C$14<=$G$14	Not Binding
$C$14	x3 >= -10, x3 <= 10	0.62791	$C$14>=$E$14	Not Binding
$C$15	x4 >= -10, x4 <= 10	-0.11628	$C$15<=$G$15	Not Binding
$C$15	x4 >= -10, x4 <= 10	-0.11628	$C$15>=$E$15	Not Binding
$C$16	x5 >= -10, x5 <= 10	0.25581	$C$16<=$G$16	Not Binding
$C$16	x5 >= -10, x5 <= 10	0.25581	$C$16>=$E$16	Not Binding
$C$9	x1 + 3*x2 = 0	0.00000	$C$9=$E$9	Binding

```
%Name: Aditya Vipradas
%ASURITE User ID: aviprada
%ASU ID: 1209435588
%Homework 1 Problem 1.a
%clear screen
clc;

%Define the objective function
fun1 = @(x)(x(1)-x(2))^2 + (x(2)+x(3)-2)^2 + (x(4)-1)^2 + (x(5)-1)^2;

%Define the initial guess
x0 = [2 2 2 2 2];

%Define the equality constraints
Aeq = [1 3 0 0 0;0 0 1 1 -2;0 1 0 0 -1];
beq = [0; 0; 0];

%Define the inequality constraints
A = [];
b = [];

%Define the upper and lower bounds
lb = [-10 -10 -10 -10 -10];
ub = [10 10 10 10 10];

x = fmincon(fun1, x0, A, b, Aeq, beq, lb, ub);
fx = (x(1)-x(2))^2 + (x(2)+x(3)-2)^2 + (x(4)-1)^2 + (x(5)-1)^2;

str1 = sprintf('The function minimizes at \n x1 = %0.5f \n x2 = %0.5f \n x3 = %0.5f \n x4 =
%0.5f \n x5 = %0.5f', x(1),x(2),x(3), x(4), x(5));
disp(str1);
str2 = sprintf('\n The minimum function value is %0.5f',fx);
disp(str2);
```

```
Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the default value of the function tolerance,
and constraints are satisfied to within the default value of the constraint tolerance.



The function minimizes at
 x1 = -0.76744
 x2 = 0.25581
 x3 = 0.62791
 x4 = -0.11628
 x5 = 0.25581

 The minimum function value is 4.09302
```

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Problem 1.b)

Use initial point: x0 = (1, 1, 1, 1) to solve:

minimize:
$24.55x1 + 26.75x2 + 39.00x3 + 40.50x4$

subject to:
$2.3x1 + 5.6x2 + 11.1x3 + 1.3x4 - 5 >= 0$
$12x1 + 11.9x2 + 41.8x3 + 52.1x4 - 21 - 1.645(0.28x1^2 + 0.19x2^2 + 20.5x3^2 + 0.62x4^2)^{1/2} >= 0$
$x1 + x2 + x3 + x4 - 1 = 0$
$0 <= xi, i = 1, ..., 4$

(Refer next page for solution using the Excel Solver and Matlab's *fmincon* solver.)

Microsoft Excel 15.0 Answer Report
Worksheet: [aviprada_hw1.xlsx]Sheet1
Report Created: 18/01/2016 8:02:46 PM
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine

Engine: GRG Nonlinear
Solution Time: 0.032 Seconds.
Iterations: 0 Subproblems: 0

Solver Options

Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Convergence 0.0001, Population Size 100, Random Seed 0, Derivatives Forward, Require Bounds
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegat

Objective Cell (Min)

Cell	Name	Original Value	Final Value
$C$24	24.55*x1 + 26.75*x2 + 39.00*x3 + 40.50*x4	130.80000	29.89438

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$C$19	x1 =	1.00000	0.63552	Contin
$C$20	x2 =	1.00000	0.00000	Contin
$C$21	x3 =	1.00000	0.31270	Contin
$C$22	x4 =	1.00000	0.05178	Contin

Constraints

Cell	Name	Cell Value	Formula	Status
$C$26	2.3*x1 + 5.6*x2 + 11.1*x3 + 1.3*x4 - 5 >= 0	0.00000	$C$26>=$E$26	Binding
$C$27	12*x1 + 11.9*x2 + 41.8*x3 + 52.1*x4 - 21 - 1.645*(0.28*x1^2 + 0.19*x2^2 + 20.5*x3^2 + 0.62*x4^2)^(1/2) >= 0	0.00000	$C$27>=$E$27	Binding
$C$28	x1 + x2 + x3 + x4 - 1 = 0	0.00000	$C$28=$E$28	Binding
$C$29	x1 >= 0	0.63552	$C$29>=$E$29	Not Binding
$C$30	x2 >= 0	0.00000	$C$30>=$E$30	Binding
$C$31	x3 >= 0	0.31270	$C$31>=$E$31	Not Binding
$C$32	x4 >= 0	0.05178	$C$32>=$E$32	Not Binding

```
%Name: Aditya Vipradas
%ASURITE User ID: aviprada
%ASU ID: 1209435588
%Homework 1 Problem 1.b

%Define nonlinear constraints in nconstraints.m file
function [c, ceq] = nconstraints(x)
    c = -1 * (12*x(1) + 11.9*x(2) + 41.8*x(3) + 52.1*x(4) - 21 - 1.645 ...
        *(0.28*x(1)^2 + 0.19*x(2)^2 + 20.5*x(3)^2 + 0.62*x(4)^2)^(1/2));
    ceq = [];
end
%clear screen
clc;

%Define the objective function
fun2 = @(x)24.55*x(1) + 26.75*x(2) + 39.00*x(3) + 40.50*x(4);
%Define the initial guess
x0 = [1 1 1 1];
%Define the equality constraints
Aeq = [1 1 1 1];
beq = [1];
%Define the inequality constraints
A = [-2.3 -5.6 -11.1 -1.3];
b = [-5];
%Define lower and upper bounds
lb = [0 0 0 0];
ub = [];

nonlcon = @nconstraints;
x = fmincon(fun2, x0, A, b, Aeq, beq, lb, ub, nonlcon);
fx = 24.55*x(1) + 26.75*x(2) + 39.00*x(3) + 40.50*x(4);

str1 = sprintf('The function minimizes at \n x1 = %0.5f',x(1));
str2 = sprintf('x2 = %0.5f \n x3 = %0.5f \n x4 = %0.5f',x(2),x(3),x(4));
disp(str1);
disp(str2);
str3 = sprintf('\n The minimum function value is %0.5f',fx);
disp(str3);
```

```
Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the default value of the function tolerance,
and constraints are satisfied to within the default value of the constraint tolerance.



The function minimizes at
 x1 = 0.63552
 x2 = 0.00000
 x3 = 0.31270
 x4 = 0.05178

 The minimum function value is 29.89438
```

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