6

October 1, 2023

1 It is a Non Linear Problem

[ ]:
```
using JuMP
import Ipopt
```

[ ]:
```
model = Model(Ipopt.Optimizer) # Using Non Linear solver
```

```
A JuMP Model
Feasibility problem with:
Variables: 0
Model mode: AUTOMATIC
CachingOptimizer state: EMPTY_OPTIMIZER
Solver name: Ipopt
```

[ ]:
```
@variable(model, l, lower_bound = 0)
```

$$l$$

[ ]:
```
@variable(model, b, lower_bound = 0)
```

$$b$$

[ ]:
```
@variable(model, h, lower_bound = 0)
```

$$h$$

[ ]:
```
corner_waste_cost = 4 * h^2
```

$$4h^2$$

[ ]:
```
welding_cost = 2 * h
```

$$2h$$

[ ]:
```
@constraint(model, l + 2 * h == 22)
```

$$l + 2h = 22$$

[ ]:
```
@constraint(model, b + 2 * h == 17)
```

$$b + 2h = 17$$

[ ]:
```
total_profit = @NLexpression(model, 8* l * b * h - corner_waste_cost -␣
↪welding_cost)
```

subexpression[1]: (8.0 * l * b * h - h * h * 4.0) - 2.0 * h

[ ]:
```
@NLobjective(model, Max, total_profit)
```

[ ]:
```
@show model
```

```
model = A JuMP Model
Maximization problem with:
Variables: 3
Objective function type: Nonlinear
`AffExpr`-in-`MathOptInterface.EqualTo{Float64}`: 2 constraints
`VariableRef`-in-`MathOptInterface.GreaterThan{Float64}`: 3 constraints
Model mode: AUTOMATIC
CachingOptimizer state: EMPTY_OPTIMIZER
Solver name: Ipopt
Names registered in the model: b, h, l
```

```
A JuMP Model
Maximization problem with:
Variables: 3
Objective function type: Nonlinear
`AffExpr`-in-`MathOptInterface.EqualTo{Float64}`: 2 constraints
`VariableRef`-in-`MathOptInterface.GreaterThan{Float64}`: 3 constraints
Model mode: AUTOMATIC
CachingOptimizer state: EMPTY_OPTIMIZER
Solver name: Ipopt
Names registered in the model: b, h, l
```

[ ]:
```
optimize!(model)
```

```
******************************************************************************
This program contains Ipopt, a library for large-scale nonlinear optimization.
 Ipopt is released as open source code under the Eclipse Public License (EPL).
         For more information visit https://github.com/coin-or/Ipopt
******************************************************************************

This is Ipopt version 3.14.13, running with linear solver MUMPS 5.6.1.
```

```
Number of nonzeros in equality constraint Jacobian…:        4
Number of nonzeros in inequality constraint Jacobian.:        0
Number of nonzeros in Lagrangian Hessian…:        6

Total number of variables…:        3
                     variables with only lower bounds:        3
                variables with lower and upper bounds:        0
                     variables with only upper bounds:        0
Total number of equality constraints…:        2
Total number of inequality constraints…:        0
        inequality constraints with only lower bounds:        0
   inequality constraints with lower and upper bounds:        0
        inequality constraints with only upper bounds:        0

iter    objective    inf_pr   inf_du lg(mu)  ||d||  lg(rg) alpha_du alpha_pr  ls
   0 -2.0391979e-02 2.20e+01 1.13e+00  -1.0 0.00e+00    -  0.00e+00 0.00e+00   0
   1 -4.1810080e+00 1.99e+01 7.69e+01  -1.0 8.54e+00    -  1.17e-03 9.28e-02h  1
   2 -2.6539272e+02 3.55e-15 3.76e+02  -1.0 7.64e+00    -  1.09e-02 1.00e+00h  1
   3  1.1296492e+03 3.55e-15 2.55e+02  -1.0 2.89e+00   2.0 6.54e-01 1.00e+00f  1
   4  3.5562631e+03 0.00e+00 6.87e+02  -1.0 1.04e+01   1.5 2.26e-01 1.00e+00f  1
   5  4.1765848e+03 0.00e+00 4.06e+01  -1.0 2.25e+00    -  1.00e+00 1.00e+00f  1
   6  4.1874980e+03 0.00e+00 9.96e-01  -1.0 3.53e-01    -  1.00e+00 1.00e+00f  1
   7  4.1875048e+03 0.00e+00 6.64e-04  -1.7 9.11e-03    -  1.00e+00 1.00e+00f  1
   8  4.1875048e+03 0.00e+00 1.78e-09  -3.8 5.85e-06    -  1.00e+00 1.00e+00f  1
   9  4.1875048e+03 0.00e+00 1.85e-11  -5.7 2.88e-09    -  1.00e+00 1.00e+00f  1
iter    objective    inf_pr   inf_du lg(mu)  ||d||  lg(rg) alpha_du alpha_pr  ls
  10  4.1875048e+03 0.00e+00 3.53e-13  -8.6 3.61e-11    -  1.00e+00 1.00e+00f  1

Number of Iterations…: 10

                                   (scaled)                 (unscaled)
Objective…:  -4.1875047654921573e+03    4.1875047654921573e+03
Dual infeasibility…:   3.5295945402507846e-13    3.5295945402507846e-13
Constraint violation…:   0.0000000000000000e+00    0.0000000000000000e+00
Variable bound violation:   0.0000000000000000e+00    0.0000000000000000e+00
Complementarity…:   2.5059035703024915e-09    2.5059035703024915e-09
Overall NLP error…:   2.5059035703024915e-09    2.5059035703024915e-09


Number of objective function evaluations             = 11
Number of objective gradient evaluations             = 11
Number of equality constraint evaluations            = 11
Number of inequality constraint evaluations          = 0
Number of equality constraint Jacobian evaluations   = 1
Number of inequality constraint Jacobian evaluations = 0
Number of Lagrangian Hessian evaluations             = 10
Total seconds in IPOPT                               = 1.358
```

```
EXIT: Optimal Solution Found.
```

[ ]:
```
@show value.(l)
```

```
value.(l) = 15.742373793241692
15.742373793241692
```

[ ]:
```
@show value.(b)
```

```
value.(b) = 10.742373793241692
10.742373793241692
```

[ ]:
```
@show value.(h)
```

```
value.(h) = 3.1288131033791533
3.1288131033791533
```

[ ]:
```
@show objective_value(model) # Max Profit
```

```
objective_value(model) = 4187.504765492157
4187.504765492157
```