

## Soluções Laboratório 1

### Questão 1 (Formulação Matemática)

#### Especificação em Julia

<http://nbviewer.jupyter.org/url/www.inf.ufrgs.br/~mrpritt/oc/distribution.ipynb>

<http://www.inf.ufrgs.br/~mrpritt/oc/distribution.jl>

A solução é

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```
using JuMP
using GLPK

me = Model(GLPK.Optimizer);

@variable(me, x[1:3] >= 0)
@variable(me, y[1:3,1:5] >= 0);

@objective(me, Max, 0.5*x[1]+1.5*x[2]+0.7*x[3]
    -0.05*y[1,1]-0.07*y[1,2]-0.11*y[1,3]-0.15*y[1,4]-0.15*y
    [1,5]
    -0.08*y[2,1]-0.06*y[2,2]-0.1*y[2,3]-0.12*y[2,4]-0.15*y
    [2,5]
    -0.1*y[3,1]-0.09*y[3,2]-0.09*y[3,3]-0.1*y[3,4]-0.16*y
    [3,5])

@constraints(me, begin
    y[1,1]+y[2,1]+y[3,1]==2700
    y[1,2]+y[2,2]+y[3,2]==2700
    y[1,3]+y[2,3]+y[3,3]==9000
    y[1,4]+y[2,4]+y[3,4]==4500
    y[1,5]+y[2,5]+y[3,5]==3600
end)

@constraints(me, begin
    y[1,1]+y[1,2]+y[1,3]+y[1,4]+y[1,5] <=4500
    y[2,1]+y[2,2]+y[2,3]+y[2,4]+y[2,5] <=9000
    y[3,1]+y[3,2]+y[3,3]+y[3,4]+y[3,5] <=11250
end)
```

```
@constraints(me, begin
    x[1]==y[1,1]+y[1,2]+y[1,3]+y[1,4]+y[1,5]
    x[2]==y[2,1]+y[2,2]+y[2,3]+y[2,4]+y[2,5]
    x[3]==y[3,1]+y[3,2]+y[3,3]+y[3,4]+y[3,5]
end)

c = [[0.05 0.07 0.11 0.15 0.15]; [0.08 0.06 0.10 0.12 0.15];
     [0.10 0.09 0.09 0.10 0.16]]
C = [4500,9000,11250]
d = [2700,2700,9000,4500,3600]
p = [2.0,1.0,1.8];

mc = Model(GLPK.Optimizer);

@variable(mc, x[1:3] >= 0)
@variable(mc, y[1:3,1:5] >= 0);

@objective(mc, Max, sum((2.5-p[i])*x[i] for i=1:3)-sum(c[i,j]*
    y[i,j] for i=1:3, j=1:5))

@constraints(mc, begin
    [j=1:5], sum(y[i,j] for i=1:3)==d[j]
    [i=1:3], sum(y[i,j] for j=1:5)<=C[i]
    [i=1:3], x[i] == sum(y[i,j] for j=1:5)
end)
```

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## Questão 2 (Formulação Matemática)

### Especificação em Julia

<http://nbviewer.jupyter.org/url/www.inf.ufrgs.br/~mrpritt/oc/metals.ipynb>  
<http://www.inf.ufrgs.br/~mrpritt/oc/metals.jl>

A solução é

---

```
using JuMP
using GLPK

m = Model(GLPK.Optimizer);
@variable(m, x[1:2] >= 0)
```

```
@objective(m, Min, 3*x[1]+6*x[2])  
  
@constraint(m, 3x[1]+2x[2] <= 18)  
  
@constraint(m, x[1]+x[2] >=5)  
  
@constraint(m, x[2] <= 7.0/8*x[1])  
  
@constraints(m ,begin  
    x[1] <= 4  
    x[2] <= 7  
end)
```

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### Questão 3 (Formulação Matemática) Especificação em Julia

<http://nbviewer.jupyter.org/url/www.inf.ufrgs.br/~mrpritt/oc/drinks.ipynb>

<http://www.inf.ufrgs.br/~mrpritt/oc/drinks.jl>

A solução é

---

```
using JuMP  
using GLPK  
  
n = 10  
ac = 10*rand(n) # acidez  
dc = 10*rand(n) # doçura  
al = 10*rand(n) # álcool  
r = 100*rand(n) # custo  
P = rand(Bool,n);  
  
m = Model(GLPK.Optimizer);  
  
@variable(m, x[1:n] >= 0)  
@variable(m, X >= 0);  
  
@objective(m, Min, sum(r[i]*x[i] for i=1:n))  
  
@constraints(m, begin  
    X == sum(x[i] for i=1:n)
```

```
X == 1
0.2 *X <= sum(ac[i]*x[i] for i=1:n)
          sum(ac[i]*x[i] for i=1:n) <= 0.3 *X
0.3 *X <= sum(ac[i]*x[i] for i=1:n)
          sum(ac[i]*x[i] for i=1:n) <= 0.4 *X
0.03*X <= sum(al[i]*x[i] for i=1:n)
          sum(al[i]*x[i] for i=1:n) <= 0.04*X
sum(x[i] for i=1:n if P[i]) >= 2*sum(x[i] for i=1:5 if !P[
  i])
end
)
```

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#### Questão 4 (Formulação Matemática) Especificação em Julia

<http://nbviewer.jupyter.org/url/www.inf.ufrgs.br/~mrpritt/oc/construction.ipynb>

<http://www.inf.ufrgs.br/~mrpritt/oc/construction.jl>

A solução é

---

```
using JuMP
using GLPK

p = [ (0,1), (1,2), (1,3), (3,4), (3,5), (2,6), (4,6), (5,7),
      (6,7), (2,8), (4,8), (7,9), (8,9) ]
d = [ 0, 2, 1, 3, 2.5, 1.5, 2, 4, 3, 0];

m = Model(GLPK.Optimizer);

@variable(m, t[1:10] >= 0)

@objective(m, Min, t[10])

@constraint(m, [pr in p], t[pr[2]+1] >= t[pr[1]+1]+d[pr[1]+1])

print(m)
```

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## Questão 5 (Formulação Matemática)

### Especificação em Julia

<http://nbviewer.jupyter.org/url/www.inf.ufrgs.br/~mrpritt/oc/police.ipynb>

<http://www.inf.ufrgs.br/~mrpritt/oc/police.jl>

A solução é

---

```
using JuMP
using GLPK

pe = [ i-1 for i=1:6]; pe[1]=6;
nm = [ 22, 55, 88, 110, 44, 33];

m = Model(GLPK.Optimizer);

@variable(m, x[1:6] >= 0)

@objective(m, Min, sum(x[i] for i=1:6))

@constraint(m, [i=1:6], x[i]+x[pe[i]] >= nm[i])
```

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