PROJECT-MATH340-1

November 29, 2021

[104]:
```
import sys
!{sys.executable} -m pip install pulp
```

```
Requirement already satisfied: pulp in /opt/conda/lib/python3.9/site-packages
(2.5.0)
```

[105]:
```
import pulp
```

[106]:
```
Lp_prob = pulp.LpProblem('ProjectLP_problem', pulp.LpMaximize)
```

[107]:
```
#Decision Variables
x_1 = pulp.LpVariable("x_1",lowBound=0, cat='Integer')
x_2 = pulp.LpVariable("x_2",lowBound=0, cat='Integer')
x_3 = pulp.LpVariable("x_3",lowBound=0, cat='Integer')
x_4 = pulp.LpVariable("x_4",lowBound=0, cat='Integer')
x_5 = pulp.LpVariable("x_5",lowBound=0, cat='Integer')
x_6 = pulp.LpVariable("x_6",lowBound=0, cat='Integer')
x_7 = pulp.LpVariable("x_7",lowBound=0, cat='Integer')
x_8 = pulp.LpVariable("x_8",lowBound=0, cat='Integer')
x_9 = pulp.LpVariable("x_9",lowBound=0, cat='Integer')
```

[108]:
```
#Objective function
Lp_prob += 25*x_1 + 40*x_2 + 60*x_3 + 25*x_4 + 40*x_5 + 60*x_6 + 25*x_7 +␣
 ↪40*x_8 + 60*x_9

#Constraints:
```

[109]:
```
#Political Capital (Coeffients)
a_11=3
a_12=5
a_13=6
a_14=-1
a_15=-1
a_16=-2
a_17=1
a_18=2
a_19=1
```

```
Lp_prob +=␣
 ↪a_11*x_1+a_12*x_2+a_13*x_3+a_14*x_4+a_15*x_5+a_16*x_6+a_17*x_7+a_18*x_8+a_19*x_9␣
 ↪<= 100
```

[110]:
```
#Traffic and Transportation Congestion
a_21=0.2
a_22=0.5
a_23=0.7
a_24=1
a_25=1
a_26=1
a_27=1
a_28=3
a_29=4

Lp_prob +=␣
 ↪a_21*x_1+a_22*x_2+a_23*x_3+a_24*x_4+a_25*x_5+a_26*x_6+a_27*x_7+a_28*x_8+a_29*x_9␣
 ↪<= 100
```

[111]:
```
#Public Sentiment
a_31=1
a_32=2
a_33=4
a_34=-2
a_35=-4
a_36=-8
a_37=0
a_38=1
a_39=1

Lp_prob +=␣
 ↪a_31*x_1+a_32*x_2+a_33*x_3+a_34*x_4+a_35*x_5+a_36*x_6+a_37*x_7+a_38*x_8+a_39*x_9␣
 ↪<= 100
```

[112]:
```
#Private Interest
a_41=0
a_42=0
a_43=0
a_44=0.5
a_45=0.3
a_46=0.2
a_47=0.5
a_48=2
a_49=4.5
```

```
Lp_prob +=␣
 ↪a_41*x_1+a_42*x_2+a_43*x_3+a_44*x_4+a_45*x_5+a_46*x_6+a_47*x_7+a_48*x_8+a_49*x_9␣
 ↪<= 100
```

[113]:
```
#Pollution/Environmental Impact
a_51=0
a_52=2
a_53=4
a_54=0
a_55=1
a_56=1
a_57=2
a_58=3
a_59=5

Lp_prob +=␣
 ↪a_51*x_1+a_52*x_2+a_53*x_3+a_54*x_4+a_55*x_5+a_56*x_6+a_57*x_7+a_58*x_8+a_59*x_9␣
 ↪<= 100
```

[114]:
```
Lp_prob += x_1 >= 0
Lp_prob += x_2 >= 0
Lp_prob += x_3 >= 0
Lp_prob += x_4 >= 0
Lp_prob += x_5 >= 0
Lp_prob += x_6 >= 0
Lp_prob += x_7 >= 0
Lp_prob += x_8 >= 0
Lp_prob += x_9 >= 0
```

[115]:
```
#print(Lp_prob)
```

[116]:
```
Lp_prob.solve()
pulp.LpStatus[Lp_prob.status]
```

```
GLPSOL: GLPK LP/MIP Solver, v4.65
Parameter(s) specified in the command line:
 --cpxlp /tmp/2153101011174e66ac37b7e43e1d2927-pulp.lp -o
/tmp/2153101011174e66ac37b7e43e1d2927-pulp.sol
Reading problem data from '/tmp/2153101011174e66ac37b7e43e1d2927-pulp.lp'…
14 rows, 9 columns, 48 non-zeros
9 integer variables, none of which are binary
41 lines were read
GLPK Integer Optimizer, v4.65
14 rows, 9 columns, 48 non-zeros
9 integer variables, none of which are binary
Preprocessing…
5 rows, 9 columns, 39 non-zeros
```

```
9 integer variables, none of which are binary
Scaling…
 A: min|aij| =  2.000e-01  max|aij| =  8.000e+00  ratio =  4.000e+01
Problem data seem to be well scaled
Constructing initial basis…
Size of triangular part is 5
Solving LP relaxation…
GLPK Simplex Optimizer, v4.65
5 rows, 9 columns, 39 non-zeros
*     0: obj =  -0.000000000e+00 inf =   0.000e+00 (9)
*     4: obj =   7.147058824e+03 inf =   0.000e+00 (0)
OPTIMAL LP SOLUTION FOUND
Integer optimization begins…
Long-step dual simplex will be used
+     4: mip =     not found yet <=              +inf        (1; 0)
Solution found by heuristic: 7120
+     9: >>>>>   7.130000000e+03 <=   7.130000000e+03   0.0% (1; 1)
+     9: mip =   7.130000000e+03 <=     tree is empty   0.0% (0; 3)
INTEGER OPTIMAL SOLUTION FOUND
Time used:   0.0 secs
Memory used: 0.1 Mb (65391 bytes)
Writing MIP solution to '/tmp/2153101011174e66ac37b7e43e1d2927-pulp.sol'…
```

[116]:
```
'Optimal'
```

[117]:
```
#Printing the final solution

for a in Lp_prob.variables():
    print(a.name, "=", a.varValue)

print("Optimal value is z = ", pulp.value(Lp_prob.objective))
```

```
x_1 = 86
x_2 = 0
x_3 = 1
x_4 = 0
x_5 = 0
x_6 = 82
x_7 = 0
x_8 = 0
x_9 = 0
Optimal value is z =  7130
```

[118]:
```
x_10 = 100 - (a_11*pulp.value(x_1)+a_12*pulp.value(x_2)+a_13*pulp.
 ↪value(x_3)+a_14*pulp.value(x_4)+a_15*pulp.value(x_5)+a_16*pulp.
 ↪value(x_6)+a_17*pulp.value(x_7)+a_18*pulp.value(x_8)+a_19*pulp.value(x_9))
```

```
x_11 = 100 - (a_21*pulp.value(x_1)+a_22*pulp.value(x_2)+a_23*pulp.
 ↪value(x_3)+a_24*pulp.value(x_4)+a_25*pulp.value(x_5)+a_26*pulp.
 ↪value(x_6)+a_27*pulp.value(x_7)+a_28*pulp.value(x_8)+a_29*pulp.value(x_9))
x_12 = 100 - (a_31*pulp.value(x_1)+a_32*pulp.value(x_2)+a_33*pulp.
 ↪value(x_3)+a_34*pulp.value(x_4)+a_35*pulp.value(x_5)+a_36*pulp.
 ↪value(x_6)+a_37*pulp.value(x_7)+a_38*pulp.value(x_8)+a_39*pulp.value(x_9))
x_13 = 100 - (a_41*pulp.value(x_1)+a_42*pulp.value(x_2)+a_43*pulp.
 ↪value(x_3)+a_44*pulp.value(x_4)+a_45*pulp.value(x_5)+a_46*pulp.
 ↪value(x_6)+a_47*pulp.value(x_7)+a_48*pulp.value(x_8)+a_49*pulp.value(x_9))
x_14 = 100 - (a_51*pulp.value(x_1)+a_52*pulp.value(x_2)+a_53*pulp.
 ↪value(x_3)+a_54*pulp.value(x_4)+a_55*pulp.value(x_5)+a_56*pulp.
 ↪value(x_6)+a_57*pulp.value(x_7)+a_58*pulp.value(x_8)+a_59*pulp.value(x_9))
```

[120]:
```
#Printing the primal optimal value



print("Primal optimal solution is x* = (", pulp.value(x_1), ",", pulp.
 ↪value(x_2), ",", pulp.value(x_3), ","
      , pulp.value(x_4), ",", pulp.value(x_5), ",",pulp.value(x_6), ",", pulp.
 ↪value(x_7), ",", pulp.value(x_8), ","
      , pulp.value(x_9), ",", x_10, ",", round(x_11,2), ",", x_12, ",", x_13,␣
 ↪",", x_14, ")")
```

```
Primal optimal solution is x* = ( 86 , 0 , 1 , 0 , 0 , 82 , 0 , 0 , 0 , 0 , 0.1
, 666 , 83.6 , 14 )
```

[ ]:
```

```