Assignment: Module 9- Goal Programming

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Solutions:

The problem has all the goals that are comparable in importance. Hence, I can say that it is an example of non-preemptive goal programming.

The Research and Development Division of the Exam Corporation has all three types of goals:

1) An upper, one-sided goal: Total profit
2) A two-sided goal: Employment Level
3) A lower, one-sided goal: Earnings next year

- As we can see there are three key factors. So let the decision variables be x1, x2 and x3

The maximize function can therefore be written as :

Maximize Z= 20x1+ 15x2 + 25x3

Similarly, the other two decision factors can be expressed as:

6x1 + 4x2 + 5x3 = 50 (Employment goal)

8x1 + 7x2 + 5x3 >= 75 (Next year's Earnings goal)

- Defining the auxiliary variables, we formulate y1 and y2

y1 = y1p – y1m, where y1p, y1m >= 0

y1p denotes the penalty for an employment level goal exceeding by 50 and y1m is the penalty for an employment level goal decreasing below 50, as mentioned in the question.

y2 = y2p -y2m, where y2p, y2m >= 0

Similarly, y2m denotes the penalty for not achieving next year's earnings and y2p represents the exceeding earnings next year.

y1 = 6x1 + 4x2 + 5x3 – 50

y2 = 8x1 + 7x2 +5x3 - 75

This concludes that we are successfully able to express management's objective function in terms of x1, x2, x3, y1+, y1-, y2+ and y2-.

- Now, we can implement the auxiliary variables and easily write the overall management objective :

Maximize Z = 20x1 + 15x2 + 25x3 – 6y1p – 6y1m – 3y2m

Subject to : 6x1 + 4x2 + 5x3 – y1p + y1m = 50

8x1 + 7x2 + 5x3 -y2p + y2m >=75

Solving this problem in R

```
#Solving the Emax linear programming model using lpsolveAPI

#loading the lpsolveAPI library
library(lpSolveAPI)
##entering the values manually
## setting up the problem with 7 decision variables, and 2 constraints.
lprec <- make.lp(2, 7)

## Setting objective function
set.objfn(lprec, c(20, 15, 25, -6, -6, 0, -3))
#Objective function is to maximise
lp.control(lprec,sense='max')

## $anti.degen
## [1] "fixedvars" "stalling"
##
## $basis.crash
## [1] "none"
##
## $bb.depthlimit
## [1] -50
##
## $bb.floorfirst
## [1] "automatic"
##
## $bb.rule
## [1] "pseudononint" "greedy"       "dynamic"      "rcostfixing"
##
## $break.at.first
## [1] FALSE
```

```
##
## $break.at.value
## [1] 1e+30
##
## $epsilon
##       epsb       epsd      epsel     epsint epsperturb   epspivot
##      1e-10      1e-09      1e-12      1e-07      1e-05      2e-07
##
## $improve
## [1] "dualfeas" "thetagap"
##
## $infinite
## [1] 1e+30
##
## $maxpivot
## [1] 250
##
## $mip.gap
## absolute relative
##    1e-11    1e-11
##
## $negrange
## [1] -1e+06
##
## $obj.in.basis
## [1] TRUE
##
## $pivoting
## [1] "devex"    "adaptive"
##
## $presolve
## [1] "none"
##
## $scalelimit
## [1] 5
##
## $scaling
## [1] "geometric"   "equilibrate" "integers"
##
## $sense
## [1] "maximize"
##
## $simplextype
## [1] "dual"   "primal"
##
## $timeout
## [1] 0
##
## $verbose
## [1] "neutral"
```

```r
##Setting values for the rows
#Left hand side constraints
set.row(lprec, 1, c(6, 4, 5, -1 , 1, 0, 0), indices = c(1, 2, 3, 4, 5, 6, 7))
set.row(lprec, 2, c(8, 7, 5,0,0,-1,1), indices = c(1, 2, 3, 4, 5, 6, 7))
#Rright hand side values
rhs <- c(50, 75)
set.rhs(lprec, rhs)

# Set constraint type and set variable types
set.constr.type(lprec, c("=", ">="))
set.bounds(lprec, lower = rep(0, 7))

#Wrting the decision variables names
lp.rownames <- c("EmploymentLevelGoal", "NextYearEarningsGoal")
lp.colnames <- c("x1", "x2", "x3","y1p", "y1m", "y2p","y2m")
dimnames(lprec) <- list(lp.rownames, lp.colnames)

# View the model
lprec

## Model name:
##                          x1    x2    x3   y1p   y1m   y2p   y2m
## Maximize                 20    15    25    -6    -6     0    -3
## EmploymentLevelGoal       6     4     5    -1     1     0     0    =  50
## NextYearEarningsGoal      8     7     5     0     0    -1     1   >=  75
## Kind                    Std   Std   Std   Std   Std   Std   Std
## Type                   Real  Real  Real  Real  Real  Real  Real
## Upper                   Inf   Inf   Inf   Inf   Inf   Inf   Inf
## Lower                     0     0     0     0     0     0     0

# Save this into a file
write.lp(lprec, filename = "emax.lp", type = "lp")

#solving the model
solve(lprec)

## [1] 0

#Show the value of objective function, variables, constraints
get.objective(lprec)

## [1] 225

get.variables(lprec)

## [1]  0  0 15 25  0  0  0

get.constraints(lprec)

## [1] 50 75
```

Findings and Observations:

1) After successfully implementing the model the values of the variables appear to be a s follows:

   x1 = 0, x2 = 0, x3 = 15, y1p = 25, y1m = 0 , y2p = 0 , y2m = 0

2) We can observe that y1 = 25 and y2 = 0, which means the second goal of next year's earnings are fully satisfied.

   But it can also be observed that the employment level goal of 50 is exceeded by 25 i. e. 2500 employees.

3) The objective function is 225. This means that the Exam Corporation needs to produ ce 15 units of product 3 (x3) and none of products 1 and 2 to achieve a profit of 225 million.