Assignment - by Kevin George

Part1

Abstract Formulation: -

SET:-

Job : Set of Job {1,2,3,4,5}

Machine: Set of Machine {1,2,3,4,5}

PARAMETER:-

 $Setup_i$: setup time for machine i \forall i \in Machine

 $Time_{ij}$: operating time for machine i to do job j \forall i \in Machine , j \in Job

 P_{ij} : presence of machine i for job j \forall i \in Machine , j \in Job

DECISION VARIABLE:-

 X_{ij} : whether machine i used for job j ->1 if used, 0 if not \forall i \in Machine , j \in Job

 Y_i : whether machine i is used -> 1 if used, 0 if not \forall i \in Machine

K: binary 1 or 0

OBJECTIVE FUNCTION:-

Minimize Time = $\sum_{i \in Machine} Setup_i * Y_i + \sum_{i \in Machine, j \in Job} Time_{ij} * X_{ij} * P_{ij}$

CONSTRAINTS:-

 $X_{ij} = 0 \text{ or } 1 \forall i \in Machine, j \in Job \{Binary Constraint\}$

 $Y_i = 0 \text{ or } 1 \forall i \in Machine \{Binary Constraint\}$

K = 0 or 1 {Binary Constraint}

 $\sum_{i \in Machine} X_{ij} * P_{ij} = 1 \ \forall j \in Job \{One job done by one machine constraint \}$

 $\sum_{i \in Job} X_{ij} * P_{ij} \le 3*Y_i \ \forall i \in Machine \{ equivalent to which all machine \}$

is selected - if machine i operates the Y_i is one }

 $X_{11} \le 1$ -K {if machine 1 is used for job1 then it is used for job3 -part2}

 $1-X_{13} \le K$ {if machine 1 is used for job1 then it is used for job3 -part1}

Concrete Formulation: -

DECISION VARIABLE: -

```
X_{11}- binary variable(1 or 0)- whether machine 1 used for job 1
X_{12}- binary variable(1 or 0)- whether machine 1 used for job 2
X_{13}- binary variable(1 or 0)- whether machine 1 used for job 3
X_{22}- binary variable(1 or 0)- whether machine 2 used for job 2
X_{23}- binary variable(1 or 0)- whether machine 2 used for job 3
X_{31}- binary variable(1 or 0)- whether machine 3 used for job 1
X_{34}- binary variable(1 or 0)- whether machine 3 used for job 4
X_{41}- binary variable(1 or 0)- whether machine 4 used for job 1
X_{43}- binary variable(1 or 0)- whether machine 4 used for job 3
X_{45}- binary variable(1 or 0)- whether machine 4 used for job 5
X_{52}- binary variable(1 or 0)- whether machine 5 used for job 2
X_{54}- binary variable(1 or 0)- whether machine 5 used for job 4
Y_1- binary variable(1 or 0)- whether machine 1 is used
Y_2- binary variable(1 or 0)- whether machine 2 is used
Y_3- binary variable(1 or 0)- whether machine 3 is used
Y_4- binary variable(1 or 0)- whether machine 4 is used
Y_5- binary variable(1 or 0)- whether machine 5 is used
K- binary variable(1 or 0)
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OBJECTIVE FUNCTION:-

```
Minimize Time = 30*Y_1 + 40*Y_2 + 50*Y_3 + 60*Y_4 + 20*Y_5 + 42*X_{11} + 70*X_{12} + 93*X_{13} + 85*X_{22} + 45*X_{23} + 58*X_{31} + 37*X_{34} + 58*X_{41} + 55*X_{43} + 38*X_{45} + 60*X_{52} + 54*X_{54}
```

CONSTRAINTS:-

```
X_{11} + X_{31} + X_{41} = 1
                                      { job 1 done by one machine constraint.}
X_{12} + X_{22} + X_{52} = 1
                                      { job 2 done by one machine constraint.}
X_{13} + X_{23} + X_{43} = 1
                                      { job 3 done by one machine constraint.}
X_{34} + X_{54} = 1
                                      { job 4 done by one machine constraint.}
X_{45} = 1
                                      { job 5 done by one machine constraint.}
X_{11} + X_{12} + X_{13} \le 3 * Y_1
                                      {if machine 1 operates the Y_1 is one}
X_{22} + X_{23} \le 3 * Y_2
                                      \{ if machine 2 operates the Y_2 is one \}
X_{31} + X_{34} \le 3 * Y_3
                                      { if machine 3 operates the Y_3 is one.}
X_{41} + X_{43} + X_{45} \le 3 * Y_4
                                      { if machine 4 operates the Y_4 is one.}
X_{52} + X_{54} \le 3 * Y_5
                                      { if machine 5 operates the Y_5 is one }
X_{11} \leq 1-K
                                      {if machine 1 is used for job1 then it is used for job3 -part2}
1-X_{13} \le K
                                      {if machine 1 is used for job1 then it is used for job3 -part1}
K = 0 \text{ or } 1
                                                                                {Binary Constraint}
Y_1, Y_2, Y_3, Y_4, Y_5 = 0 \text{ or } 1
                                                                               {Binary Constraint}
X_{11}, X_{12}, X_{13}, X_{22}, X_{23}, X_{31}, X_{34}, X_{41}, X_{43}, X_{45}, X_{52}, X_{54} = 0 or 1
                                                                               {Binary Constraint}
```

OPTIMAL SOLUTION & INTERPRETATION.

$$\begin{array}{l} Y_1,Y_2Y_3\!=\!0\\ Y_4\!=\!1,Y_5\!=\!1\\ X_{41},X_{43},X_{45},X_{52},X_{54}\!=\!1\\ X_{11},X_{12},\!X_{13},\!X_{22},\!X_{23},X_{31},\!X_{34}=\!0\\ \mathrm{K}\!=\!1\\ \mathrm{Objective\ function=345} \end{array}$$

- 1) For the problem optimal solution says that only machine 4 and 5 is only on and rest are off. (from the Y_i values we got 1 if "on" 0 if "off")
- 2) Also the job 1, job 3 and job 5 is done by machine 4. And Job 2 and Job 4 is done by machine 5.
- 3) We got the least time for operating and setting up of machine. The value 345 is the summation of least operating time for each job and setting up of each machine which is operating

Part2

 $y_1 = 0$

 $y_2 = 0$

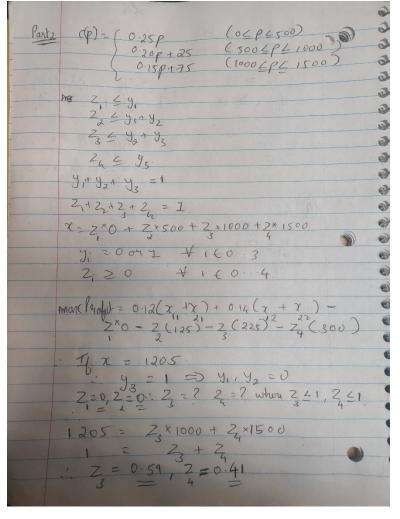
 $y_3 = 1$

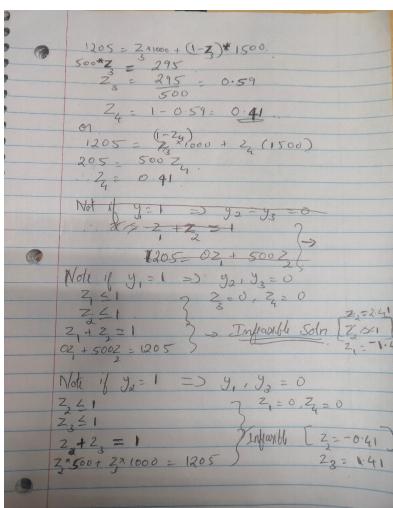
z_1=0

z_2 =0

 $z_3 = 0.59$

 $z_4 = 0.41$





Part3

PROBLEM FORMULATION

DECISION VARIABLE:-

- H- Number of Single Home Sold
- D- Number of Duplex Sold
- Z1- Piecewise function variable1
- Z2- Piecewise function variable2
- Z3- Piecewise function variable3
- Z4 Piecewise function variable4
- Y1 Piecewise function binary variable1
- Y2 Piecewise function binary variable2
- Y3 Piecewise function binary variable3

OBJECTIVE FUNCTION:-

Maximize Profit =0* Z1+3000000* Z2+7050000* Z3+15800000*Z4+ 140000*H -85000* D-90000* H

CONSTRAINTS:-

```
D+H<=120 {max unit to be built.}

3* D >= H {Duplex to house ratio}

D+1.75*H<=150 {acres of land constraint}

Z1<=Y1 {Piecewise function constraint for selling price of Duplex}

Z2<=Y1+Y2 { Piecewise function constraint for selling price of Duplex }

Z3<=Y2+Y3 { Piecewise function constraint for selling price of Duplex }

Z4<= Y3 { Piecewise function constraint for selling price of Duplex }

Y1+ Y2+ Y3=1 { Piecewise function constraint for selling price of Duplex }

Z1+ Z2+ Z3+ Z4=1 { Piecewise function constraint for selling price of Duplex }

0*.Z1+20* Z2+50* Z3+120* Z4 = D { Piecewise function constraint for selling price of Duplex }

H,D >= 0 {Non Negative Integer Constraint}

Z1,Z2,Z3,Z4 >= 0 {Non Negative Real Constraint}

Y1,Y2,Y3 = 0 or 1 {Binary Constraint}
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//The commented PYOMO model is attached

OPTIMAL SOLUTION & INTERPRETATION.

- H- Number of Single Home Sold = 40
- D- Number of Duplex Sold =80
- Z1- Piecewise function variable1=0
- Z2- Piecewise function variable2=0

- Z3- Piecewise function variable3=0.571
- Z4 Piecewise function variable4=0.428
- Y1 Piecewise function binary variable1=0
- Y2 Piecewise function binary variable2=0
- Y3 Piecewise function binary variable3=1

Maximized Profit is \$ 6000000.

Hint:- Selling Price(SP) for Duplex (D) equation:-

SP= 150000*D for (0≤D≤20)

 $SP=135000*D + 300000 \text{ for } (20 \le D \le 50)$

 $SP=125000*D + 800000 \text{ for } (50 \le D \le 120)$