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1)
First step: decision variables is x1 , x2 , x3 that is the number of produced basket type one and type two and type three respectively.

Second step is finding our objective function.
max z = 50x1 + 30x2 + 60x3 and z is our sales profit.

Third step is finding all constrains over our variables:
30x1 + 10x2 + 20x2 <= 100
20x1 + 40x2 + 15x3 <= 800
4x1 + 3x2 + 10x3 <= 100

Forth step is finding our restrictions over type and sing of our variable (real or integer, positive or negative)
x1, x2, x3 >= 0
gin x1 x2 x3
! if we write gin we don't need "x1, x2, x3 >= 0" any more, but there is no problem with solution

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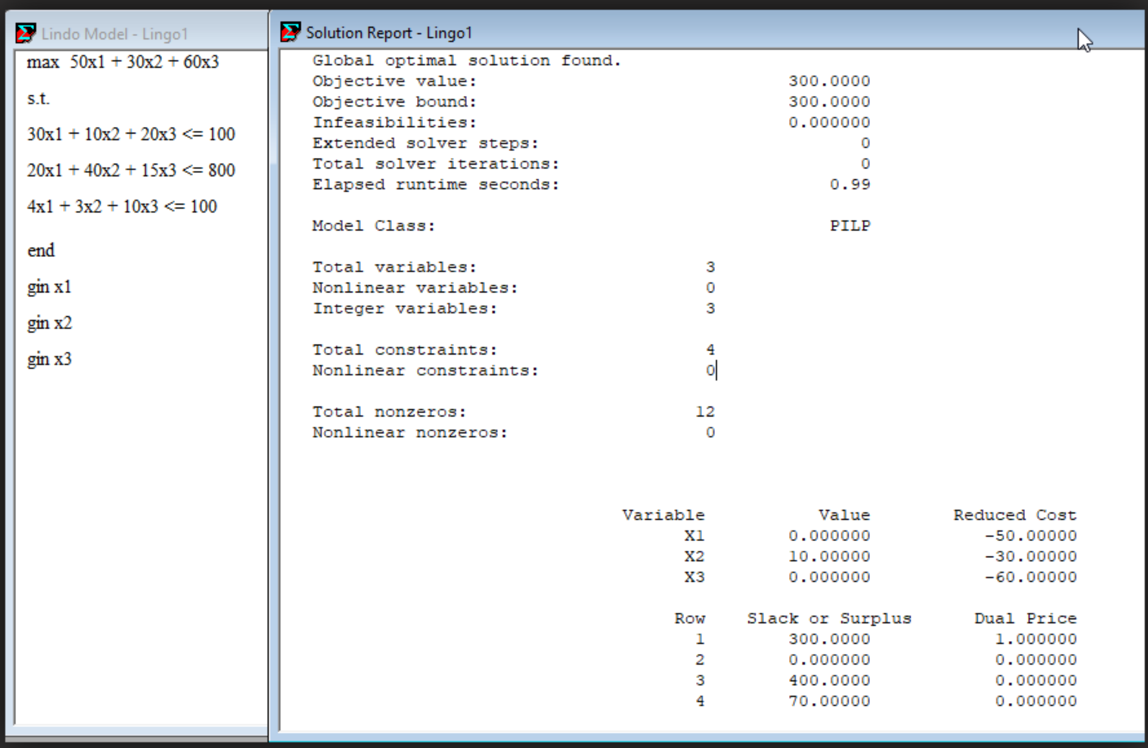

Lindo Model - Lingo1

```
max 50x1 + 30x2 + 60x3

s.t.

30x1 + 10x2 + 20x3 <= 100

20x1 + 40x2 + 15x3 <= 800

4x1 + 3x2 + 10x3 <= 100

end

gin x1

gin x2

gin x3
```

Solution Report - Lingo1

```
Global optimal solution found.
Objective value:                              300.0000
Objective bound:                              300.0000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
Elapsed runtime seconds:                          0.99

Model Class:                                      PILP

Total variables:                     3
Nonlinear variables:                 0
Integer variables:                   3

Total constraints:                   4
Nonlinear constraints:               0

Total nonzeros:                     12
Nonlinear nonzeros:                  0


                          Variable           Value        Reduced Cost
                                X1        0.000000           -50.00000
                                X2        10.00000           -30.00000
                                X3        0.000000           -60.00000

                               Row    Slack or Surplus      Dual Price
                                 1        300.0000            1.000000
                                 2        0.000000            0.000000
                                 3        400.0000            0.000000
                                 4        70.00000            0.000000
```

I find another solution for this problem intuitively that is x3 =5 but Lingo didn't tell about that. Why ???

12) if each cutting had a cost for us we should cosider all possible cutting model
and if the cost of 20 foot and 17 foot was different we must multiplied their cutting model number with corresponding cost in objective function
Our coutting models:

نوع برش	تعداد قطعه‌های ۳ فوتی	تعداد قطعه‌های ۵ فوتی	تعداد قطعه‌های ۹ فوتی	میزان ضایعات (بر حسب فوت)
۱	۵	۰	۰	۲
۲	۴	۱	۰	۰
۳	۲	۲	۰	۱
۴	۲	۰	۱	۲
۵	۱	۱	۱	۰
۶	۰	۳	۰	۲

Cutting model	Num 3 foot	Numb of 5 foot	Numb of 9 foot	Exact wasted wood
Y1	6	0	0	2
Y2	5	1	0	0
Y3	3	2	0	1
Y4	3	0	1	2
Y5	2	1	1	0
Y6	1	3	0	2
Y7	0	4	0	0
Y8	0	2	1	1
Y9	0	0	2	2

because each cut haven't any cost for us,I intuitively considered models that have a "exact waste" less that our smallest peace of wood (means 3)

Min X1+x2+x3+x4+x5+x6+Y1+Y2+Y3+Y4+Y5+Y6+Y7+Y8+Y9
s.t.

5X1+4x2+2x3+2x4+1x5+6Y1+5Y2+3Y3+3Y4+2Y5+1Y6>=25
x2+2x3+x5+3x6+1Y2+2Y3+1Y5+3Y6+4Y7+2Y8>=20
x4+x5+Y4+Y5+Y8+2Y9>=15
end
gin X1,x2,x3,x4,x5,x6,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9

```
Global optimal solution found.
Objective value:                              16.00000
Objective bound:                              16.00000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             7
Elapsed runtime seconds:                          0.47

Model Class:                                      PILP

Total variables:                    15
Nonlinear variables:                 0
Integer variables:                  15

Total constraints:                   4
Nonlinear constraints:               0

Total nonzeros:                     42
Nonlinear nonzeros:                  0
```

Variable	Value	Reduced Cost
X1	0.000000	1.000000
X2	0.000000	1.000000
X3	0.000000	1.000000
X4	0.000000	1.000000
X5	0.000000	1.000000
X6	0.000000	1.000000
Y1	0.000000	1.000000
Y2	0.000000	1.000000
Y3	0.000000	1.000000
Y4	0.000000	1.000000
Y5	13.00000	1.000000
Y6	0.000000	1.000000
Y7	1.000000	1.000000
Y8	2.000000	1.000000
Y9	0.000000	1.000000

Row	Slack or Surplus	Dual Price
1	16.00000	-1.000000
2	1.000000	0.000000
3	1.000000	0.000000
4	0.000000	0.000000

```
Min x1+x2+x3+x4+x5+x6+Y1+Y2+Y3+Y4+Y5+Y6+Y7+Y8+Y9
s.t.

5X1+4x2+2x3+2x4+1x5+6Y1+5Y2+3Y3+3Y4+2Y5+1Y6>=25

x2+2x3+x5+3x6+1Y2+2Y3+1Y5+3Y6+4Y7+2Y8>=20

x4+x5+Y4+Y5+Y8+2Y9>=15

end

gin x1

gin x2

gin x3

gin x4

gin x5

gin x6

gin Y1

gin Y2

gin Y3

gin Y4

gin Y5

gin Y6

gin Y7

gin Y8

gin Y9
```

3) Global optimal solution found.

Objective value:	5370.000
Objective bound:	5370.000
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	9
Elapsed runtime seconds:	1.16
Model Class:	PILP
Total variables:	21
Nonlinear variables:	0
Integer variables:	21
Total constraints:	15
Nonlinear constraints:	0
Total non zeros:	91
Nonlinear non zeros:	0

Front table means we must hire (8+2+4+5=) 19 people for our company and distribute them in a week days in this order 8-0-2-4-0-5-0 means in first day 8 people should start their work and so on. Also extra work for i'th day is showed by yi and wi.
For example y1=5 means the 5 people that started their work in day 1 must go extra work at day six and w1=0 means we don't need any people that started its work in first day to work in day number 7 and so on

Variable	Value	Reduced Cost
X1	8.000000	250.0000
X2	0.000000	250.0000
X3	2.000000	250.0000
X4	4.000000	250.0000
X5	0.000000	250.0000
X6	5.000000	250.0000
X7	0.000000	250.0000
Y1	5.000000	62.00000
Y2	0.000000	62.00000
Y3	0.000000	62.00000
Y4	0.000000	62.00000
Y5	0.000000	62.00000
Y6	5.000000	62.00000
Y7	0.000000	62.00000
W1	0.000000	62.00000
W2	0.000000	62.00000
W3	0.000000	62.00000
W4	0.000000	62.00000
W5	0.000000	62.00000
W6	0.000000	62.00000
W7	0.000000	62.00000

Row	Slack or Surplus	Dual Price
1	5370.000	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.000000	0.000000
9	3.000000	0.000000
10	0.000000	0.000000
11	2.000000	0.000000
12	4.000000	0.000000
13	0.000000	0.000000
14	0.000000	0.000000
15	0.000000	0.000000

```
Min 250x1+250x2+250x3+250x4+250x5+250x6+250x7+62y1+62y2+62y3+62y4+62y5+62y6+
62y7+62w1+62w2+62w3+62w4+62w5+62w6+62w7

s.t.
x1+x7+x6+x5+x4+y3+w2>=17
x2+x1+x7+x6+x5+w3+y4>=13
x3+x2+x1+x7+x6+w4+y5>=15
x4+x3+x2+x1+x7+w5+y6>=19
x5+x4+x3+x2+x1+w6+y7>=14
x6+x5+x4+x3+x2+w7+y1>=16
x7+x6+x5+x4+x3+w1+y2>=11
y1+w1-x1<=0
y2+w2-x2<=0
y3+w3-x3<=0
y4+w4-x4<=0
y5+w5-x5<=0
y6+w6-x6<=0
y7+w7-x7<=0
end
gin x1
gin x2
gin x3
gin x4
gin x5
gin x6
gin x7
gin y1
gin y2
gin y3
gin y4
gin y5
gin y6
gin y7
gin w1
gin w2
gin w3
gin w4
gin w5
gin w6
gin w7
```

Xi means number of people that start their work at the I’th day
yi means number of people that start their work at I’th day and will work extra at 5 days after their start day

And Wi is number of people that start their work at I’th day and will work extra at 6 days after their start da

5)

we have tree layer of decision and in each layer we have 3 and 3 and 5 element respectively. So we must hase 3*3*5=45 decesion variables. But we are lucky because we can assume that some event (variables) in our models are with probability of zero, in other word (for example we have not any road from W1 to C2 or we have not any road from C1 to receiver 3,4,5):

fisrt layer:

Name of workshop	Total ability for production	Production decision varables name
1	400	W1
2	400	W2
3	400	W3

Second layer for first workshop:

Name of rode	Cost for that	Number of production passed by this center decision variable name
(1,1)	C(1,1)	C1
(1,2)	Infinite*	C2
(1,3)	C(1,3)	C3

(1,1) means from first workshop to first center

C(i,j) is a parametric cost

* Infinite =probabilty zero for this event , if we want to use literature of probability theory

And in same way we have some non zero probability decision variables in third layer.

And finaly we must multiply all of these layers's variables to get a final variable.

So we have 22 decision variables:

W1c1r1 , W1c1r2 , W1c3r3 , W1c3r4, W1c3r5

W2c1r1, W2c1r2, W2c2r1, W2c2r2, W2c2r3, W2c2r4, W2c2r5, W2c3r3, W2c3r4, W2c3r5

W3c1r1, W3c1r2, W3c2r1, W3c2r2, W3c2r3, W3c2r4, W3c2r5

and each decesion variable has its own cost coefficient

cost coefficient for xicjrk is (C(i,j)+d(j,k)) and xicjrk means number of production that we must produce in I'th **w**orkshop and sent to j'th **C**enter and then use k'th road to send to the k'th **r**eceiver

our conditions is satisfying that we don't produce more than 400 in each workshop (<=) and also checking that we send enough (or exact – means using = instead of >=) product to each costumer.

Min (C(1,1)+d(1,1)) W1c1r1 + (C(1,1)+d(1,k2)) W1c1r2 +(C(1,3)+d(3,3)) W1c3r3 + (C(1,3)+d(3,4)) W1c3r4 + (C(1,3)+d(3,5)) W1c3r5 + (C(2,1)+d(1,1)) W2c1r1+ (C(2,1)+d(1,2)) W2c1r2+ (C(2,2)+d(2,1)) W2c2r1+ (C(2,2)+d(2,2)) W2c2r2+ (C(2,2)+d(2,3)) W2c2r3+ (C(2,2)+d(2,4)) W2c2r4+ (C(2,2)+d(2,5)) W2c2r5+ (C(2,3)+d(3,3)) W2c3r3+ (C(2,3)+d(3,4)) W2c3r4+ (C(2,3)+d(3,5)) W2c3r5+ (C(3,1)+d(1,1)) W3c1r1, (C(3,1)+d(1,2)) W3c1r2, (C(3,2)+d(2,1)) W3c2r1+(C(3,2)+d(2,2)) W3c2r2+ (C(3,2)+d(2,3)) W3c2r3+ (C(3,2)+d(2,4)) W3c2r4+ (C(3,2)+d(2,5)) W3c2r5 s.t.

W1c1r1 + W1c1r2 + W1c3r3 + W1c3r4n+ W1c3r5 <=400

W2c1r1+ W2c1r2+ W2c2r1+ W2c2r2 +W2c2r3+ W2c2r4+ W2c2r5+ W2c3r3+ W2c3r4+ W2c3r5 <= 400

W3c1r1+ W3c1r2+ W3c2r1+ W3c2r2+ W3c2r3+ W3c2r4+ W3c2r5 <= 400

W1c1r1+ W2c1r1+ W3c1r1+ W3c2r1+ W2c2r1 =100

W1c1r2+ W2c1r2+ W3c1r2+ W2c2r2+ W3c2r2 = 200

W1c3r3 + W2c2r3+ W3c2r3+ W2c3r3 =150

W1c3r4+ W2c2r4+ W3c2r4+ W2c3r4 =50

W1c3r5 +W2c2r5+ W2c3r5+ W3c2r5 = 300

End

Gin(All variables)