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CS325
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Homework #6

Problem 1:

a) Find the distance of the shortest path from G to C in the graph below.

The shortest distance of the path from G to C: 16

```
max dc
ST        dg = 0
          dg - de <= 7
          dh - dg <= 3
          da - dh <= 4
          da - df <= 5
          df - da <= 10
          db - da <= 8
          db - dh <= 9
          de - db <= 10
          dd - de <= 9
          de - dd <= 25
          dd - dc <= 3
          dc - db <= 4
          db - df <= 7
          dd - dg <= 2
          df - dd <= 18
          de - df <= 2
end
```

```
LP OPTIMUM FOUND AT STEP      6

       OBJECTIVE FUNCTION VALUE

       1)      16.00000

 VARIABLE        VALUE          REDUCED COST
       DC        16.000000          0.000000
       DG         0.000000          0.000000
       DE         0.000000          0.000000
       DH         3.000000          0.000000
       DA         4.000000          0.000000
       DF         5.000000          0.000000
       DB        12.000000          0.000000
       DD         0.000000          0.000000


      ROW   SLACK OR SURPLUS     DUAL PRICES
       2)         0.000000          1.000000
       3)         7.000000          0.000000
       4)         0.000000          1.000000
       5)         3.000000          0.000000
       6)         6.000000          0.000000
       7)         9.000000          0.000000
       8)         0.000000          0.000000
       9)         0.000000          1.000000
      10)        22.000000          0.000000
      11)         9.000000          0.000000
      12)        25.000000          0.000000
      13)        19.000000          0.000000
      14)         0.000000          1.000000
      15)         0.000000          0.000000
      16)         2.000000          0.000000
      17)        13.000000          0.000000
      18)         7.000000          0.000000

NO. ITERATIONS=       6
```

b) Find the distances of the shortest paths from G to all other vertices.

G -> D = 2

G -> H = 3

G -> A = 7

G -> B = 12

G -> C = 16

G -> F = 17

G -> E = 19

```
max da + db + dc + dd + de + df + dh
ST      dg = 0
        dg - de <= 7
        dh - dg <= 3
        da - dh <= 4
        da - df <= 5
        df - da <= 10
        db - da <= 8
        db - dh <= 9
        de - db <= 10
        dd - de <= 9
        de - dd <= 25
        dd - dc <= 3
        dc - db <= 4
        db - df <= 7
        dd - dg <= 2
        df - dd <= 18
        de - df <= 2
end
```

```
LP OPTIMUM FOUND AT STEP      5

       OBJECTIVE FUNCTION VALUE

       1)      76.00000

 VARIABLE        VALUE          REDUCED COST
       DA         7.000000          0.000000
       DB        12.000000          0.000000
       DC        16.000000          0.000000
       DD         2.000000          0.000000
       DE        19.000000          0.000000
       DF        17.000000          0.000000
       DH         3.000000          0.000000
       DG         0.000000          0.000000

      ROW   SLACK OR SURPLUS     DUAL PRICES
       2)         0.000000          7.000000
       3)        26.000000          0.000000
       4)         0.000000          6.000000
       5)         0.000000          3.000000
       6)        15.000000          0.000000
       7)         0.000000          2.000000
       8)         3.000000          0.000000
       9)         0.000000          2.000000
      10)         3.000000          0.000000
      11)        26.000000          0.000000
      12)         8.000000          0.000000
      13)        17.000000          0.000000
      14)         0.000000          1.000000
      15)        12.000000          0.000000
      16)         0.000000          1.000000
      17)         3.000000          0.000000
      18)         0.000000          1.000000

NO. ITERATIONS=       5
```

Problem 2:

```
max 3.45s + 2.32p + 2.81b + 3.25c
ST
        0.125s <= 1000
        0.08p + 0.05b + 0.03c <= 2000
        0.05b + 0.07c <= 1250

        s >= 6000
        s <= 7000
        p >= 10000
        p <= 14000
        b >= 13000
        b <= 16000
        c >= 6000
        c <= 8500
END
```

```
LP OPTIMUM FOUND AT STEP      4

       OBJECTIVE FUNCTION VALUE

       1)      120196.0

 VARIABLE        VALUE          REDUCED COST
        S      7000.000000          0.000000
        P     13625.000000          0.000000
        B     13100.000000          0.000000
        C      8500.000000          0.000000

      ROW   SLACK OR SURPLUS     DUAL PRICES
       2)       125.000000          0.000000
       3)         0.000000         29.000000
       4)         0.000000         27.200001
       5)      1000.000000          0.000000
       6)         0.000000          3.450000
       7)     12625.000000          0.000000
       8)       375.000000          0.000000
       9)       100.000000          0.000000
      10)      2900.000000          0.000000
      11)      2500.000000          0.000000
      12)         0.000000          0.476000

NO. ITERATIONS=       4
```

Optimal number of ties of each type:

1) Silk = 7000
2) Blend 1 = 13100

3) Blend 2 = 8500
4) Polyester = 13625

Maximum profit = 120196.00

Problem 3:

Part A)

Let X_{ij} = quantity shipped from plant p_i to warehouse w_j

Let X_{jk} = quantity shipped from warehouse w_j to retailer r_k

$$\Sigma\Sigma x_{ij} * cp(ij) + \Sigma\Sigma x_{jk} * cw(jk)$$

Objective Function:

Σx1j = 150 (p1)
Σx2j = 450 (p2)
Σx3j = 250 (p3)
Σx4j = 150 (p4)

Σxi1 - Σx1k = 0 (w)
Σxi2 - Σx2k = 0 (w2)
Σxi3 - Σx3k = 0 (w3)

Σxj1 = 100 (r1)
Σxj2 = 150 (r2)
Σxj3 = 100 (r3)
Σxj4 = 200 (r4)
Σxj5 = 200 (r5)
Σxj6 = 150 (r6)
Σxj7 = 100 (r7)

xij, xjk >= 0

Vertices	Supply	Demand
P1	150	150
P2	450	450
P3	250	250
P4	150	150
W1	0	0
W2	0	0
W3	0	0
R1	-100	-100
R2	-150	-150
R3	-100	-100
R4	-200	-200
R5	-100	-100
R6	-150	-150
R7	-100	-100

Starting Point	Destination	Cost	Destination Supply
P1	W1	10	150
P1	W2	15	0
P2	W1	11	200
P2	W2	8	250
P3	W1	13	0
P3	W2	8	150
P3	W3	9	100
P4	W2	14	0
P4	W3	8	150
W1	R1	5	100
W1	R2	6	150
W1	R3	7	100
W1	R4	10	0
W2	R3	12	0
W2	R4	8	200
W2	R5	10	200
W2	R6	14	0
W3	R4	14	0
W3	R5	12	0
W3	R6	12	150
W3	R7	6	100

Optimal Cost	17100

Results (Plant to warehouse):
P1 -> W1 = 150
P2 -> W1 = 200
P2 -> W2 = 250
P3 -> W2 = 150
P3 -> W3 = 100
P4 -> W3 = 150

Warehouse to retailers:
W1 -> R1 = 100
W1 -> R2 = 150
W1 -> R3 = 100
W2 -> R4 = 200
W2 -> R5 = 200
W3 -> R6 = 150
W3 -> R7 = 100

Total Optimum Cost = $17100

Part B)

Vertices	Supply | Demand	
P1	150	150
P2	450	450
P3	250	250
P4	150	150
W1	0	0
W3	0	0
R1	-100	-100
R2	-150	-150
R3	-100	-100
R4	-200	-200
R5	-100	-100
R6	-150	-150
R7	-100	-100

Starting Point	Destination	Cost	Destination Supply
P1	W1	10	150
P2	W1	11	200
P3	W1	13	0
P3	W3	9	100
P4	W3	8	150
W1	R1	5	100
W1	R2	6	150
W1	R3	7	100
W3	R4	14	0
W3	R5	12	0
W3	R6	12	150
W3	R7	6	100

Optimal Cost 17950

(Model without warehouse 2)

Optimal solution for plant to warehouse:
P1 -> W1 = 150
P2 -> W1 = 400
P3 -> W3 = 250
P4 -> W3 = 150

Warehouse(W1 and W3) to retailers:
W1 -> R1 = 100
W1 -> R2 = 150
W1 -> R3 = 100
W1 -> R4 = 200
W3 -> R5 = 200
W3 -> R6 = 150
W3 -> R7 = 50

Optimal total cost = $17950, not feasible because it cost an extra $850 to ship the refrigerators to the remaining warehouses.

PART C:

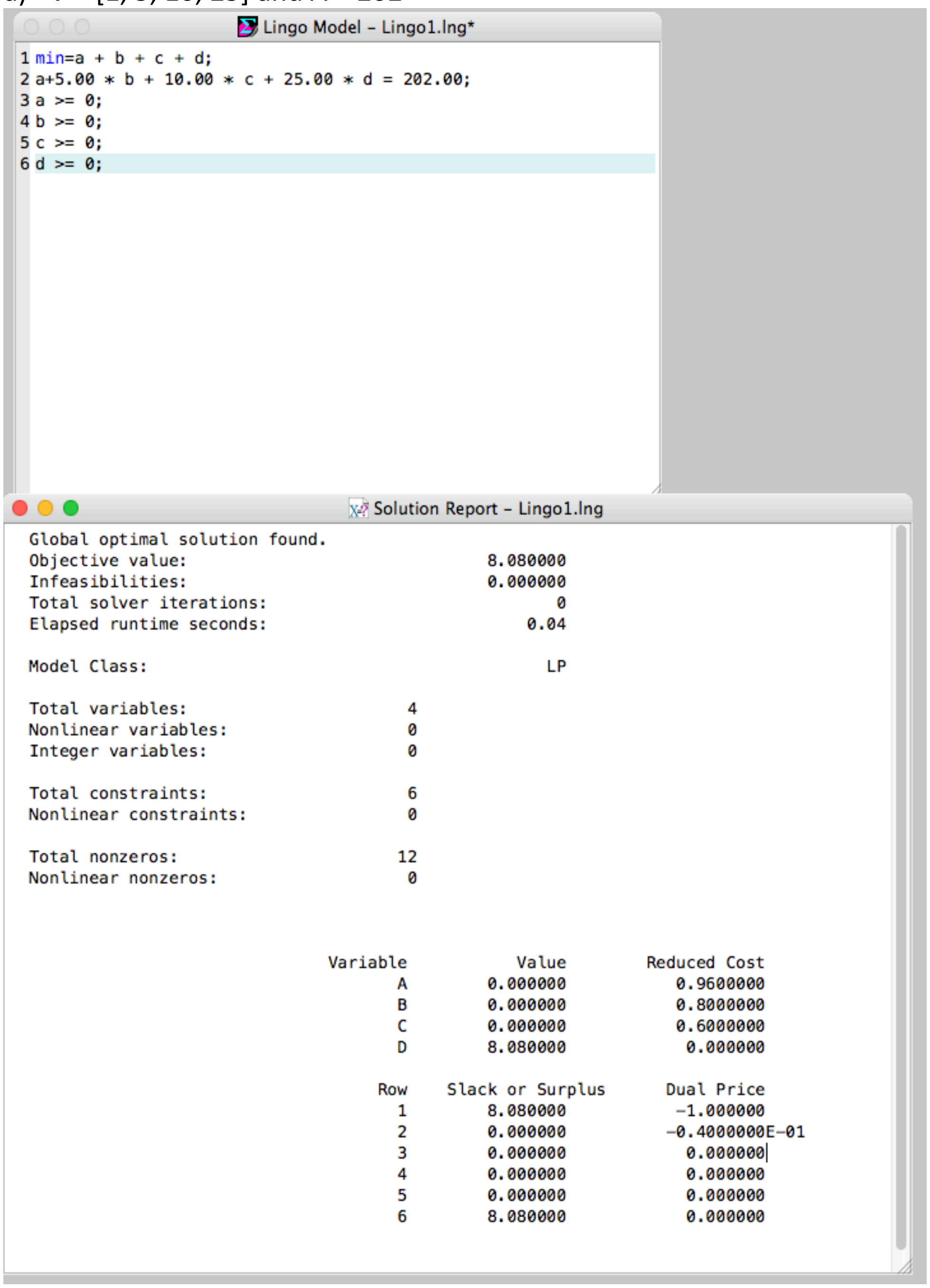
Vertices	Supply | Demand	
P1	150	150
P2	450	450
P3	250	250
P4	150	150
W1	0	0
W2	0	0
W3	0	0
R1	-100	-100
R2	-150	-150
R3	-100	-100
R4	-200	-200
R5	-100	-100
R6	-150	-150
R7	-100	-100

Starting Point	Destination	Cost	Destination Supply
P1	W1	10	150
P1	W2	15	0
P2	W1	11	350
P2	W2	8	100
P3	W1	13	0
P3	W2	8	0
P3	W3	9	150
P4	W2	14	0
P4	W3	8	150
W1	R1	5	100
W1	R2	6	150
W1	R3	7	100
W1	R4	10	0
W2	R3	12	0
W2	R4	8	200
W2	R5	10	0
W2	R6	14	0
W3	R4	14	0
W3	R5	12	100
W3	R6	12	150
W3	R7	6	100
Optimal Cost	16000		

Results for Part C are feasible that has an optimal total cost: $16000 from the limited shipments.

Problem 4:

a) V = [1, 5, 10, 25] and A = 202



Lingo Model – Lingo1.lng*

```
1 min=a + b + c + d;
2 a+5.00 * b + 10.00 * c + 25.00 * d = 202.00;
3 a >= 0;
4 b >= 0;
5 c >= 0;
6 d >= 0;
```

Solution Report – Lingo1.lng

```
Global optimal solution found.
Objective value:                              8.080000
Infeasibilities:                              0.000000
Total solver iterations:                             0
Elapsed runtime seconds:                          0.04

Model Class:                                        LP

Total variables:                      4
Nonlinear variables:                  0
Integer variables:                    0

Total constraints:                    6
Nonlinear constraints:                0

Total nonzeros:                      12
Nonlinear nonzeros:                   0


                          Variable           Value        Reduced Cost
                                 A        0.000000           0.9600000
                                 B        0.000000           0.8000000
                                 C        0.000000           0.6000000
                                 D        8.080000            0.000000

                               Row    Slack or Surplus      Dual Price
                                 1        8.080000           -1.000000
                                 2        0.000000      -0.4000000E-01
                                 3        0.000000            0.000000
                                 4        0.000000            0.000000
                                 5        0.000000            0.000000
                                 6        8.080000            0.000000
```

Minimum number of coins = 10

1 coin = 2, 5 coin = 0, 10 coin = 0, 25 coin = 8

b) V = [1, 3, 7, 12, 27] and A = 293

Lingo Model – Lingo1.lng*

```
min=a + b + c + d + e;
a + 3 * b + 7 * c + 12 * d + 27 * e = 293;
a >= 0;
b >= 0;
c >= 0;
d >= 0;
e >= 0;
```

Solution Report – Lingo1.lng

```
Global optimal solution found.
Objective value:                              10.85185
Infeasibilities:                              0.000000
Total solver iterations:                             0
Elapsed runtime seconds:                          0.02

Model Class:                                        LP

Total variables:                      5
Nonlinear variables:                  0
Integer variables:                    0

Total constraints:                    7
Nonlinear constraints:                0

Total nonzeros:                      15
Nonlinear nonzeros:                   0


                              Variable           Value        Reduced Cost
                                     A        0.000000           0.9629630
                                     B        0.000000           0.8888889
                                     C        0.000000           0.7407407
                                     D        0.000000           0.5555556
                                     E        10.85185            0.000000

                                   Row    Slack or Surplus      Dual Price
                                     1        10.85185           -1.000000
                                     2        0.000000      -0.3703704E-01
                                     3        0.000000            0.000000
                                     4        0.000000            0.000000
                                     5        0.000000            0.000000
                                     6        0.000000            0.000000
                                     7        10.85185            0.000000
```

Minimum coins used = 14

1 coin = 1, 3 coin = 1, 7 coin = 1, 12 coin = 1, 27 coin = 10