CS 325 Homework Assignment 6
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11/6/17

1 Shortest paths can be cast as an LP using distances dv from the sour s to a particular vertex v as variables.

We can compute the shortest path from s to t in a weighted directed graph by solving:

max dt

subject to

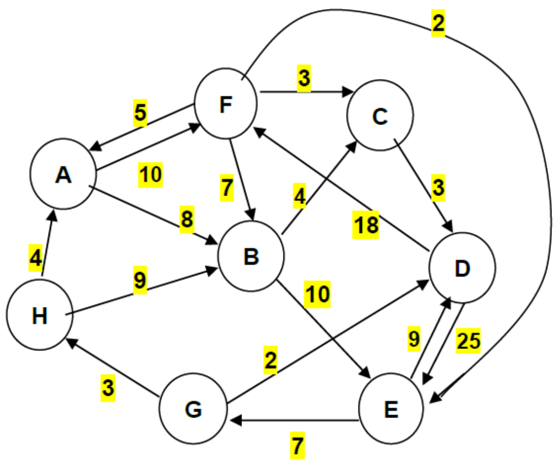
ds = 0

dv – du <= w(u,v) for all (u,v) in E

We can compute the single source by changing the objective function to:

max Summation$_{\text{v in V}}$ dv

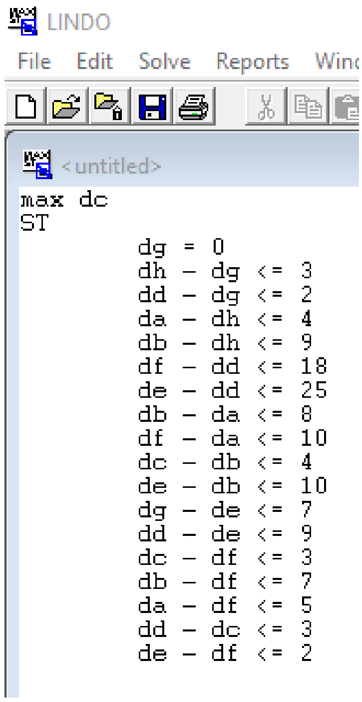
Use linear programming to answer the questions below. Submit a copy of the LP code and output.



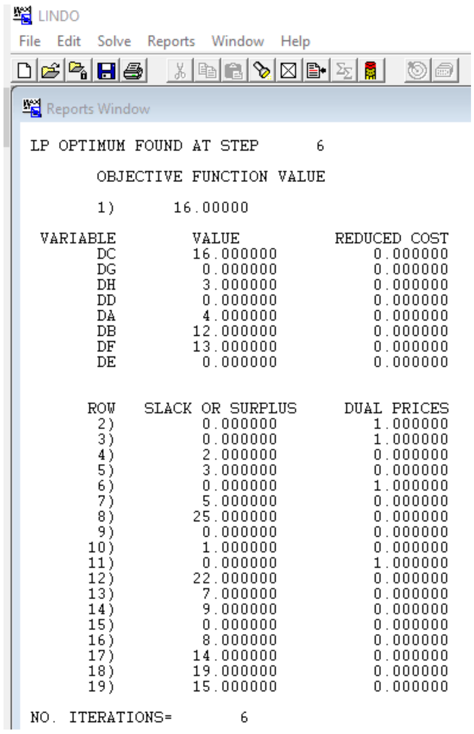
a) Find the distance of the shortest path from G to C in the graph above

The distance of the shortest path from G to C is 16.

LP code and output is on the following page…



```
LINDO
File  Edit  Solve  Reports  Winc
<untitled>
max dc
ST
        dg = 0
        dh - dg <= 3
        dd - dg <= 2
        da - dh <= 4
        db - dh <= 9
        df - dd <= 18
        de - dd <= 25
        db - da <= 8
        df - da <= 10
        dc - db <= 4
        de - db <= 10
        dg - de <= 7
        dd - de <= 9
        dc - df <= 3
        db - df <= 7
        da - df <= 5
        dd - dc <= 3
        de - df <= 2
```

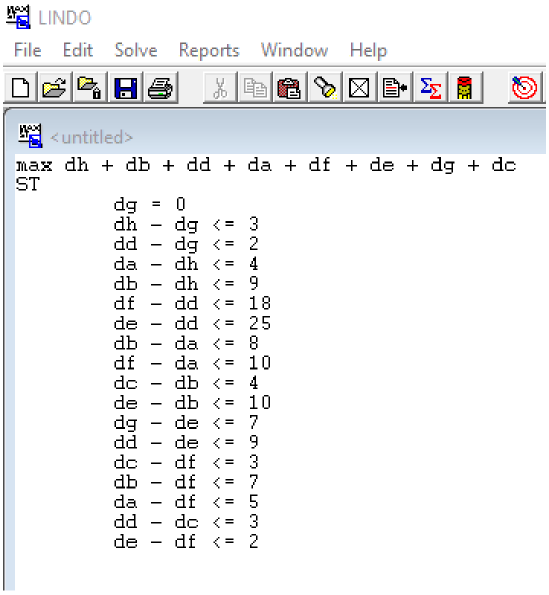


```
LINDO
File  Edit  Solve  Reports  Window  Help
Reports Window

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
       DH         3.000000          0.000000
       DD         0.000000          0.000000
       DA         4.000000          0.000000
       DB        12.000000          0.000000
       DF        13.000000          0.000000
       DE         0.000000          0.000000


      ROW   SLACK OR SURPLUS     DUAL PRICES
       2)         0.000000          1.000000
       3)         0.000000          1.000000
       4)         2.000000          0.000000
       5)         3.000000          0.000000
       6)         0.000000          1.000000
       7)         5.000000          0.000000
       8)        25.000000          0.000000
       9)         0.000000          0.000000
      10)         1.000000          0.000000
      11)         0.000000          1.000000
      12)        22.000000          0.000000
      13)         7.000000          0.000000
      14)         9.000000          0.000000
      15)         0.000000          0.000000
      16)         8.000000          0.000000
      17)        14.000000          0.000000
      18)        19.000000          0.000000
      19)        15.000000          0.000000

NO. ITERATIONS=       6
```

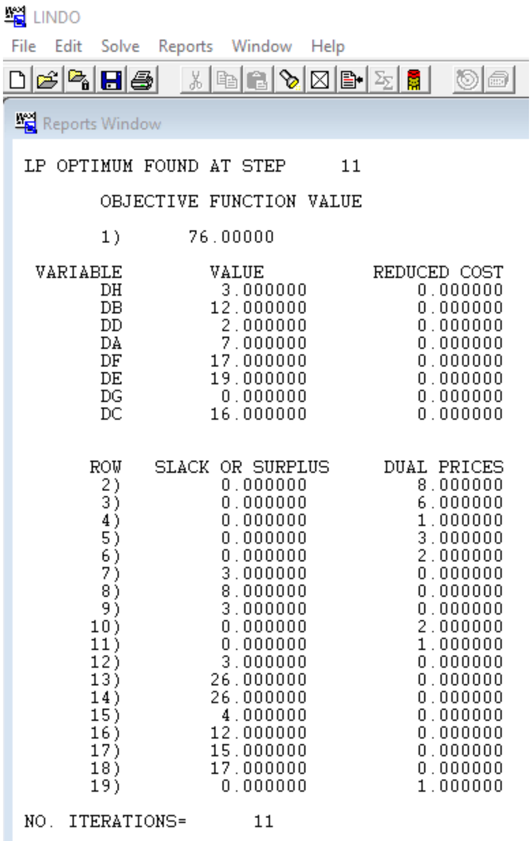
b) Find the distances of the shortest paths from G to all other vertices

The shortest path distance from G to A is 7.
The shortest path distance from G to B is 12.
The shortest path distance from G to C is 16.
The shortest path distance from G to D is 2.
The shortest path distance from G to E is 19.
The shortest path distance from G to F is 17.
The shortest path distance from G to G is 0.
The shortest path distance from G to H is 3.

LP code and output on the following page…



```
LINDO
File  Edit  Solve  Reports  Window  Help
<untitled>
max dh + db + dd + da + df + de + dg + dc
ST
        dg = 0
        dh - dg <= 3
        dd - dg <= 2
        da - dh <= 4
        db - dh <= 9
        df - dd <= 18
        de - dd <= 25
        db - da <= 8
        df - da <= 10
        dc - db <= 4
        de - db <= 10
        dg - de <= 7
        dd - de <= 9
        dc - df <= 3
        db - df <= 7
        da - df <= 5
        dd - dc <= 3
        de - df <= 2
```



```
LINDO
File  Edit  Solve  Reports  Window  Help
Reports Window
 LP OPTIMUM FOUND AT STEP      11

        OBJECTIVE FUNCTION VALUE

        1)      76.00000

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


       ROW   SLACK OR SURPLUS     DUAL PRICES
        2)         0.000000          8.000000
        3)         0.000000          6.000000
        4)         0.000000          1.000000
        5)         0.000000          3.000000
        6)         0.000000          2.000000
        7)         3.000000          0.000000
        8)         8.000000          0.000000
        9)         3.000000          0.000000
       10)         0.000000          2.000000
       11)         0.000000          1.000000
       12)         3.000000          0.000000
       13)        26.000000          0.000000
       14)        26.000000          0.000000
       15)         4.000000          0.000000
       16)        12.000000          0.000000
       17)        15.000000          0.000000
       18)        17.000000          0.000000
       19)         0.000000          1.000000

 NO. ITERATIONS=      11
```

2 Acme Industries produces four types of men's ties using three types of material. Your job is to determine how many of each type of tie to make each month. The goal is to maximize profit, profit per tie = selling price – labor cost – material cost. Labor cost is $0.75 per tie for all four types of ties. The material requirements and costs are given below.

Material	**Cost per yard**	**Yards available per month**
Silk	$20	1,000
Polyester	$6	2,000
Cotton	$9	1,250

Product Information	**Type of Tie**			
	Silk = s	**Poly = p**	**Blend1 = b**	**Blend2 = c**
Selling Price per tie	$6.70	$3.55	$4.31	$4.81
Monthly Minimum units	6,000	10,000	13,000	6,000
Monthly Maximum units	7,000	14,000	16,000	8,500

Material Information in yards	Type of Tie			
	Silk	Polyester	Blend 1 (50/50)	Blend 2 (30/70)
Silk	0.125	0	0	0
Polyester	0	0.08	0.05	0.03
Cotton	0	0	0.05	0.07

type	selling price	labor	material	profit per tie
silk s	6.7	0.75	2.5	3.45
poly p	3.55	0.75	0.48	2.32
blend1 b	4.31	0.75	0.75	2.81
blend2 c	4.81	0.75	0.81	3.25

Formulate the problem as a linear program with an objective function and all constraints. Determine the optimal solution for the linear program using any software you want. What are the optimal numbers of ties of each type to maximize profit? Include a copy of the code and output.

Goal: maximize profit (profit for each of the four types of ties)
Profit per tie = selling price – labor cost – material cost
Profit for 1 silk tie = 3.45
Profit for 1 Polyester tie = 2.32
Profit for 1 Blend 1 tie = 2.81
Profit for 1 Blend 2 tie = 3.25
x1 = silk, x2 = Polyester, x3 = Blend 1, x4 = Blend 2

Using the above information, this problem can be formulated as a linear program with an objective function and all of the constraints by the following:

Maximize Profit = 3.45x1 + 2.32x2 + 2.81x3 + 3.25x4
Subject To
    0.125x1 <= 1000 (constraint on yards avail. for silk)
    .08x2 + .05x3 + .03x4 <= 2000 (constraint on yards avail. for polyester)
    .05x3 + .07x4 <= 1250 (constraint on yards avail. for cotton)
    x1 >= 6000 (constraint on min. silk ties)
    x1 <= 7000 (constraint on max. silk ties)
    x2 >= 10000 (constraint on min. polyester ties)
    x2 <= 14000 (constraint on max. polyester ties)
    x3 >= 13000 (constraint on min. blend 1 ties)
    x3 <= 16000 (constraint on max. blend 1 ties)
    x4 >= 6000 (constraint on min. blend 2 ties)
    x4 <= 8500 (constraint on max. blend 2 ties)
    x1, x2, x3, x4 >= 0 (constraint on no non-negative tie amounts)

The optimal solution (max. profit) for this linear program is: $120196.00

The optimal numbers of ties of each type to maximize profit is the following:

\# of silk ties → 7000
\# of polyester ties → 13625
\# of blend 1 ties → 13100
\# of blend 2 ties → 8500

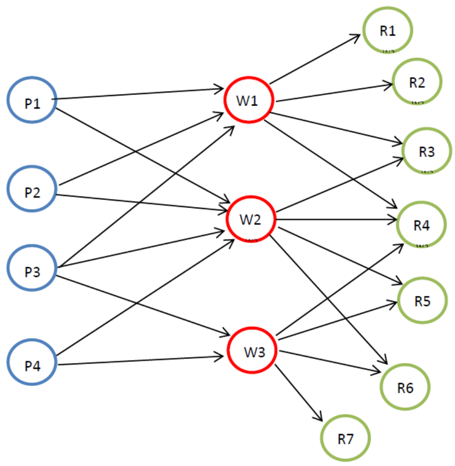
LP code and output below…

```
max 3.45x1 + 2.32x2 + 2.81x3 + 3.25x4
ST
          .125x1 <= 1000
          .08x2 + .05x3 + .03x4 <= 2000
          .05x3 + .07x4 <= 1250
          x1 >= 6000
          x1 <= 7000
          x2 >= 10000
          x2 <= 14000
          x3 >= 13000
          x3 <= 16000
          x4 >= 6000
          x4 <= 8500
          x1 >= 0
          x2 >= 0
          x3 >= 0
          x4 >= 0
```

```
        OBJECTIVE FUNCTION VALUE

        1)      120196.0

  VARIABLE        VALUE          REDUCED COST
        X1      7000.000000          0.000000
        X2     13625.000000          0.000000
        X3     13100.000000          0.000000
        X4      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)      3625.000000          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
       13)      7000.000000          0.000000
       14)     13625.000000          0.000000
       15)     13100.000000          0.000000
       16)      8500.000000          0.000000

 NO. ITERATIONS=       4
```

3 This is an extension of the transportation model. There are now intermediate transshipment points added between the sources (plants) and destinations (retailers). Items being shipped from a Plant (pi) must be shipped to a Warehouse (wj) before being shipped to the Retailer (rk). Each plant will have an associated supply (si) and each retailer will have a demand (dk). The number of plants is n, number of warehouses is q and the number of retailers is m. The edges (i,j) from plant (pi) to warehouse (wj) have costs associated denoted cp(i,j). The edges (j,k) from a warehouse (wj) to a retailer (rk) have costs associated denoted cw(j,k).

The graph below shows the transshipment map for a manufacturer of refrigerators. Refrigerators are produced at four plants and then shipped to a warehouse (weekly) before going to the retailer.



Below are the costs of shipping from a plant to a warehouse and then a warehouse to a retailer. If it is impossible to ship between the two locations an X is placed in the table.

cost	W1	W2	W3
P1	$10	$15	X
P2	$11	$8	X
P3	$13	$8	$9
P4	X	$14	$8

cost	R1	R2	R3	R4	R5	R6	R7
W1	$5	$6	$7	$10	X	X	X
W2	X	X	$12	$8	$10	$14	X
W3	X	X	X	$14	$12	$12	$6

The tables below give the capacity of each plant (supply) and the demand for each retailer (per week).

	P1	P2	P3	P4
Supply	150	450	250	150

	R1	R2	R3	R4	R5	R6	R7
Demand	100	150	100	200	200	150	100

Your goal is to determine the number of refrigerators to be shipped plants to warehouses and then warehouses to retailers to minimize the cost. Formulate the problem as a linear program with an objective function and all constraints. Determine the optimal solution for the linear program using any software you want. What are the optimal shipping routes and minimum cost. Include a copy of the code and output.

Goal: Minimize the cost of shipping refrigerators from plants to warehouses to retailers. To do this we need to add up all of the costs per each possible route (plants to warehouses and warehouses to retailers). We then take the min. of this total amount with using the constraints of the supply and demand for the plants and retail locations.

This problem can be formulated as a linear program with an objective function and all constraints in the following manner:

Minimize Cost = 10(p1w1) + 15(p1w2) + 11(p2w1) + 8(p2w2) + 13(p3w1) + 8(p3w2) + 9(p3w3) + 14(p4w2) + 8(p4w3) + 5(w1r1) + 6(w1r2) + 7(w1r3) + 12(w2r3) + 10(w1r4) + 8(w2r4) + 14(w3r4) + 10(w2r5) + 12(w3r5) + 14(w2r6) + 12(w3r6) + 6(w3r7)

Subject to

p1w1 + p1w2 <= 150
p2w1 + p2w2 <= 450
p3w1 + p3w2 + p3w3 <= 250
p4w2 + p4w3 <= 150

w1r1 >= 100
w1r2 >= 150
w1r3 + w2r3 >= 100
w1r4 + w2r4 + w3r4 >= 200
w2r5 + w3r5 >= 200
w2r6 + w3r6 >= 150
w3r7 >= 100

w1r1 + w1r2 + w1r3 + w1r4 – p1w1 – p2w1 – p3w1 = 0
w2r3 + w2r4 + w2r5 + w2r6 – p1w2 – p2w2 – p3w2 – p4w2 = 0
w3r4 + w3r5 + w3r6 + w3r7 – p3w3 -p4w3 = 0

p1w1, p1w2, p2w1, p2w2, p3w1, p3w2, p3w3, p4w2, p4w3, w1r1, w1r2, w1r3, w2r3, w1r4, w2r4, w3r4, w2r5, w3r5, w2r6, w3r6, w3r7 >= 0

The optimal solution (minimal cost) for this linear program is: $17100.00

The optimal shipping routes are as follows:
p1 to w1 (150 units)
p2 to w1 (200 units)
p2 to w2 (250 units)
p3 to w2 (150 units)
p3 to w3 (100 units)
p4 to w3 (150 units)
w1 to r1 (100 units)
w1 to r2 (150 units)
w1 to r3 (100 units)
w2 to r4 (200 units)
w2 to r5 (200 units)

w3 to r6 (150 units)
w3 to r7 (100 units)

Note: p = plant, w = warehouse, r = retailer and refrigerators are the units

LP code and output below…

LINDO

File Edit Solve Reports Window Help

<untitled>

```
min 10 p1w1 + 15 p1w2 + 11 p2w1 + 8 p2w2 + 13 p3w1 +
8 p3w2 + 9 p3w3 + 14 p4w2 + 8 p4w3 + 5 w1r1 + 6 w1r2 +
7 w1r3 + 12 w2r3 + 10 w1r4 + 8 w2r4 + 14 w3r4 + 10 w2r5 +
12 w3r5 + 14 w2r6 + 12 w3r6 + 6 w3r7
ST
        p1w1 + p1w2 <= 150
        p2w1 + p2w2 <= 450
        p3w1 + p3w2 + p3w3 <= 250
        p4w2 + p4w3 <= 150

        w1r1 >= 100
        w1r2 >= 150
        w1r3 + w2r3 >= 100
        w1r4 + w2r4 + w3r4 >= 200
        w2r5 + w3r5 >= 200
        w2r6 + w3r6 >= 150
        w3r7 >= 100

        w1r1 + w1r2 + w1r3 + w1r4 - p1w1 - p2w1 - p3w1 = 0
        w2r3 + w2r4 + w2r5 + w2r6 - p1w2 - p2w2 - p3w2 - p4w2 = 0
        w3r4 + w3r5 + w3r6 + w3r7 - p3w3 - p4w3 = 0

        p1w1 >= 0
        p1w2 >= 0
        p2w1 >= 0
        p2w2 >= 0
        p3w1 >= 0
        p3w2 >= 0
        p3w3 >= 0
        p4w2 >= 0
        p4w3 >= 0
        w1r1 >= 0
        w1r2 >= 0
        w1r3 >= 0
        w2r3 >= 0
        w1r4 >= 0
        w2r4 >= 0
        w3r4 >= 0
        w2r5 >= 0
        w3r5 >= 0
        w2r6 >= 0
        w3r6 >= 0
        w3r7 >= 0
```

LINDO

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Reports Window

```
        OBJECTIVE FUNCTION VALUE

        1)      17100.00

  VARIABLE        VALUE          REDUCED COST
      P1W1       150.000000          0.000000
      P1W2         0.000000          8.000000
      P2W1       200.000000          0.000000
      P2W2       250.000000          0.000000
      P3W1         0.000000          2.000000
      P3W2       150.000000          0.000000
      P3W3       100.000000          0.000000
      P4W2         0.000000          7.000000
      P4W3       150.000000          0.000000
      W1R1       100.000000          0.000000
      W1R2       150.000000          0.000000
      W1R3       100.000000          0.000000
      W2R3         0.000000          2.000000
      W1R4         0.000000          5.000000
      W2R4       200.000000          0.000000
      W3R4         0.000000          7.000000
      W2R5       200.000000          0.000000
      W3R5         0.000000          3.000000
      W2R6         0.000000          1.000000
      W3R6       150.000000          0.000000
      W3R7       100.000000          0.000000


       ROW   SLACK OR SURPLUS     DUAL PRICES
        2)         0.000000          1.000000
        3)         0.000000          0.000000
        4)         0.000000          0.000000
        5)         0.000000          1.000000
        6)         0.000000        -16.000000
        7)         0.000000        -17.000000
        8)         0.000000        -18.000000
        9)         0.000000        -16.000000
       10)         0.000000        -18.000000
       11)         0.000000        -21.000000
       12)         0.000000        -15.000000
       13)         0.000000         11.000000
       14)         0.000000          8.000000
       15)         0.000000          9.000000
       16)       150.000000          0.000000
       17)         0.000000          0.000000
       18)       200.000000          0.000000
       19)       250.000000          0.000000
       20)         0.000000          0.000000
       21)       150.000000          0.000000
       22)       100.000000          0.000000
       23)         0.000000          0.000000
       24)       150.000000          0.000000
       25)       100.000000          0.000000
       26)       150.000000          0.000000
       27)       100.000000          0.000000
       28)         0.000000          0.000000
       29)         0.000000          0.000000
       30)       200.000000          0.000000
       31)         0.000000          0.000000
       32)       200.000000          0.000000
       33)         0.000000          0.000000
       34)         0.000000          0.000000
       35)       150.000000          0.000000
       36)       100.000000          0.000000

 NO. ITERATIONS=        4
```

Minimum cost is $17100.00

4 Veronica the owner of Very Veggie Vegeria is creating a new healthy salad that is low in calories but meets certain nutritional requirements. A salad is any combination of the following ingredients: tomato, lettuce, spinach, carrot, smoked tofu, sunflower seeds, chickpeas, oil

Each salad must contain:

- At least 15 grams of protein
- At least 2 and at most 8 grams of fat
- At least 4 grams of carbohydrates
- At most 200 milligrams of sodium
- At least 40% leafy greens by mass

The nutritional contents of these ingredients (per 100 grams) and cost are:

Ingredient	Energy (Cal)	Protein (grams)	Fat (grams)	Carbohydrate (grams)	Sodium (mg)	Cost (100g)
Tomato	21	0.85	0.33	4.64	9.00	$1.00
Lettuce	16	1.62	0.20	2.37	28.00	$0.75
Spinach	40	2.86	0.39	3.63	65.00	$0.50
Carrot	41	0.93	0.24	9.58	69.00	$0.50
Sunflower Seeds	585	23.4	48.7	15.00	3.80	$0.45
Smoked Tofu	120	16.00	5.00	3.00	120.00	$2.15
Chickpeas	164	9.00	2.6	27.0	78.00	$0.95
Oil	884	0	100.00	0	0	$2.00

Part A: Determine the combination of ingredients that minimizes calories but meets all nutritional requirements. Formulate the problem as a linear program with an objective function and all constraints. Determine the optimal solution for the linear program using any software you want. What is the cost of the low calorie salad? Include a copy of the code and output.

Goal: Minimize calories but still meet the nutritional requirements. To do this we need to add up all of the total calories per ingredient. We then take the min. of that total amount with using the constraints of the protein, fat, carbohydrates, sodium and leafy greens percentage.

This problem can be formulated as a linear program with an objective function and all constraints in the following manner:

Minimize Calories = 21T + 16L + 40S + 41C + 585SS + 120ST + 164CP + 884O

Subject to

.85T + 1.62L + 2.86S + 0.93C + 23.4SS + 16ST + 9CP >= 15 (protein)
.33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O >= 2 (fat min)
.33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O <= 8 (fat max)

4.64T + 2.37L + 3.63S + 9.58C + 15SS + 3ST + 27CP >= 4 (carbs)
9T + 28L + 65S + 69C + 3.8SS + 120ST + 78CP <= 200 (sodium)
.6L + .6S - .4T - .4C - .4SS - .4ST - .4CP - .4O >= 0 (leafy greens %)

The optimal solution (min. calorie salad) is a 114.75 calorie salad. The combination of ingredients that makes up this salad while still meeting the nutritional requirements is: Lettuce (0.585) and Smoked Tofu (0.878). The cost of this low calorie salad is $2.33.

The cost was derived by: (0.75*0.585) + (2.15*0.878) = 2.33

The LP code and output to this problem is below…

```
LINDO
File  Edit  Solve  Reports  Window  Help
<untitled>
min 21T + 16L + 40S + 41C + 585SS + 120ST + 164CP + 884O
ST
        .85T + 1.62L + 2.86S + 0.93C + 23.4SS + 16ST + 9CP >= 15
        .33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O >= 2
        .33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O <= 8
        4.64T + 2.37L + 3.63S + 9.58C + 15SS + 3ST + 27CP >= 4
        9T + 28L + 65S + 69C + 3.8SS + 120ST + 78CP <= 200
        .6L + .6S - .4T - .4C - .4SS - .4ST - .4CP - .4O >= 0
```

```
LINDO
File  Edit  Solve  Reports  Window  Help
Reports Window

 LP OPTIMUM FOUND AT STEP      12

        OBJECTIVE FUNCTION VALUE

        1)      114.7541

  VARIABLE        VALUE          REDUCED COST
         T         0.000000         16.901640
         L         0.585480          0.000000
         S         0.000000         14.513662
         C         0.000000         36.289616
        SS         0.000000        408.387970
        ST         0.878220          0.000000
        CP         0.000000         97.551910
         O         0.000000        886.404358


       ROW   SLACK OR SURPLUS     DUAL PRICES
        2)         0.000000         -7.650273
        3)         2.508197          0.000000
        4)         3.491803          0.000000
        5)         0.022248          0.000000
        6)        78.220139          0.000000
        7)         0.000000         -6.010929

 NO. ITERATIONS=      12
```

Part B: Veronica realizes that it is also important to minimize the cost associated with the new salad. Unfortunately some of the ingredients can be expensive. Determine the combination of ingredients that minimizes cost. Formulate the problem as a linear program with an objective function and all constraints. Determine the optimal solution for the linear program using any software you want. How many calories are in the low cost salad? Include a copy of the code and output.

Goal: Minimize cost of ingredients for salad that still meets the requirements. To do this we need to add up the total cost of each ingredient. We then take the min. of that total amount with using the constraints of the protein, fat, carbohydrates, sodium and leafy greens percentage.

This problem can be formulated as a linear program with an objective function and all constraints in the following manner:

Minimize Cost = 1T + .75L + .5S + .5C + .45SS + 2.15ST + .95CP + 2O

Subject to

.85T + 1.62L + 2.86S + 0.93C + 23.4SS + 16ST + 9CP >= 15 (protein)
.33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O >= 2 (fat min)
.33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O <= 8 (fat max)
4.64T + 2.37L + 3.63S + 9.58C + 15SS + 3ST + 27CP >= 4 (carbs)
9T + 28L + 65S + 69C + 3.8SS + 120ST + 78CP <= 200 (sodium)
.6L + .6S - .4T - .4C - .4SS - .4ST - .4CP - .4O >= 0 (leafy greens %)

The optimal solution (min. salad cost) is $1.55. The combination of ingredients that makes up this salad while still meeting the nutritional requirements is: Spinach (0.832), Sunflower Seeds (0.096) and Chickpeas (1.152). In this low cost salad, there are 278.49 calories.

The LP code and output to this problem is on the following page…

LINDO

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```
min 1T + .75L + .5S + .5C + .45SS + 2.15ST + .95CP + 2O
ST
        .85T + 1.62L + 2.86S + 0.93C + 23.4SS + 16ST + 9CP >= 15
        .33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O >= 2
        .33T + .2L + .39S + .24C + 48.7SS + 5ST + 2.6CP + 100O <= 8
        4.64T + 2.37L + 3.63S + 9.58C + 15SS + 3ST + 27CP >= 4
        9T + 28L + 65S + 69C + 3.8SS + 120ST + 78CP <= 200
        .6L + .6S - .4T - .4C - .4SS - .4ST - .4CP - .4O >= 0
```

LINDO

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Reports Window

```
 LP OPTIMUM FOUND AT STEP        3

        OBJECTIVE FUNCTION VALUE

        1)       1.554133

  VARIABLE        VALUE          REDUCED COST
         T         0.000000          1.002081
         L         0.000000          0.402912
         S         0.832298          0.000000
         C         0.000000          0.486914
        SS         0.096083          0.000000
        ST         0.000000          0.405609
        CP         1.152364          0.000000
         O         0.000000          7.281258


       ROW   SLACK OR SURPLUS     DUAL PRICES
        2)         0.000000         -0.131261
        3)         6.000000          0.000000
        4)         0.000000          0.051847
        5)        31.576324          0.000000
        6)        55.651089          0.000000
        7)         0.000000         -0.241358

 NO. ITERATIONS=        3
```