

## Solutions to First Test Practice Questions

### 1 Snowboard luggage

- $x_1$  = Units of small luggage produced  
 $x_2$  = Units of medium luggage produced  
 $x_3$  = Units of large luggage produced  
 $t$  = Dollars spent on trade promotions  
 $d$  = Dollars spent on direct promotions

$$\begin{aligned} \max \quad & 25x_1 + 40x_2 + 50x_3 \\ & -12[0.8x_1 + x_2 + 1.1x_3] \\ & -3[3x_1 + 5x_2 + 8x_3] \\ & - (t + d) \\ \text{ST} \quad & 0.8x_1 + x_2 + 1.1x_3 \leq 2500 \\ & 3x_1 + 5x_2 + 8x_3 \leq 9000 \\ & x_1 \leq 500 + 0.1t + 0.12d \\ & x_2 \leq 1000 + 0.1t + 0.1d \\ & x_3 \leq 750 + 0.1t + 0.08d \\ & x_1, x_2, x_3, t, d \geq 0 \end{aligned}$$

### 2 Production, inventory, and advertising

(a) = B15 + D\$4\*E14 + D\$3\*E15

(b) = I14 + F15 + G15 - H15

(c) D22 = D1\*SUM(H15:H20)  
D23 = SUMPRODUCT(C15:C20,F15:F20)  
D24 = SUMPRODUCT(C15:C20,G15:G20) + D9\*SUM(G15:G20)  
D25 = SUM(E15:E20)  
D26 = D2\*SUM(I15:I20)  
D27 = D22 - SUM(D23:D26)

(d) Target cell is D27, maximize  
E15:E20 <= D6  
F15:F20 <= D7  
G15:G20 <= D8  
I15:I20 >= 0  
I15:I20 <= D11  
Assume nonnegative *or* E15:E20 >= 0, F15:F20 >= 0, G15:G20 >= 0  
Assume linear model

### 3 Production, Shipping, and Inventory

- $x_{ij}$  = Number of units shipped from supplier  $i = 1, 2, 3$  to distributor  $j = 1, 2, 3$   
 $a_0$  = Dollars spent on national advertising  
 $a_j$  = Dollars spend on regional advertising for distributor  $j$   
 $y_i$  = Number of units ordered from supplier  $i = 1, 2, 3$  (optional “helper” variables)

$$\begin{aligned}
 \max \quad & 49.95(y_1 + y_2 + y_3) \\
 & - [23.5y_1 + 17.9y_2 + 21y_3] \\
 & - [2.3x_{11} + 3.25x_{12} + \dots + 2.85x_{33}] \\
 & - [a_0 + a_1 + a_2 + a_3] \\
 \text{ST} \quad & y_1 = x_{11} + x_{12} + x_{13} \\
 & y_2 = x_{21} + x_{22} + x_{23} \\
 & y_3 = x_{31} + x_{32} + x_{33} \\
 & x_{11} + x_{21} + x_{31} = 8000 + \frac{2}{100}a_0 + \frac{8}{100}a_1 \\
 & x_{12} + x_{22} + x_{32} = 5000 + \frac{3}{100}a_0 + \frac{6}{100}a_2 \\
 & x_{13} + x_{23} + x_{33} = 7500 + \frac{4}{100}a_0 + \frac{5}{100}a_3 \\
 & y_1 \leq 0.5(y_1 + y_2 + y_3) \\
 & y_2 \leq 0.5(y_1 + y_2 + y_3) \\
 & y_3 \leq 0.5(y_1 + y_2 + y_3) \\
 & y_1 \leq 25,000 \\
 & y_2 \leq 10,000 \\
 & y_3 \leq 12,000 \\
 & x_{11}, \dots, x_{33}, a_0, a_1, a_2, a_3, y_1, y_2, y_3 \geq 0
 \end{aligned}$$

(Note:  $y_1, y_2, y_3 \geq 0$  are not really necessary because of the first three constraints.)

### 4 Making goat cheese

- (a) The uncontrollable inputs are in B2:E13 and D15:D22.  
 (b) = D25 + C2\*B26 - C26  
 (c) = (1 - D\$19)\*B25  
 (d) = (1 + D\$19)\*B25  
 (e) B36 = SUM(B24:B35)  
 (f) C36 = SUM(C24:C35) (or just copy cell B368)  
 (g) = D18\*B38  
 (h) D38 = D15\*C36  
 D39 = SUMPRODUCT(B2:B13,B24:B35)  
 D40 = B36\*D16  
 D41 = D18\*SUM(D24:D35)  
 D42 = D38 - SUM(D39:D41)

(i) Target cell is D42, maximize

Changing cells are B24:C35

B24:B35  $\leq$  D17 (milk processing limit)

C24:C35  $\geq$  D2:D13 (minimum cheese sales)

C4:C35  $\leq$  E2:E13 (maximum cheese sales)

D24:D35  $\geq$  0 (ending inventory)

Assume linear model

If you examine the model, you may conclude that “assume nonnegative” isn’t necessary because of all the other constraints that are present. However, there is no harm in including “assume nonnegative”. The constraint D24:D35  $\geq$  0 ensures that you will not sell more cheese than you have available.

## 5 Choosing a class schedule

$x_i = 1$  if Shelly takes course  $i = 1, \dots, 10$ , otherwise 0.

$$\begin{array}{ll} \max & 10x_1 + 8x_2 + \dots + 6x_{10} \\ \text{ST} & 14 \leq 3x_1 + 3x_2 + 3x_3 + 4x_4 + 3x_5 + \dots + 4x_{10} \leq 17 \quad (\text{credits}) \\ & 6x_1 + 8x_2 + 5x_3 + \dots + 8x_{10} \leq 30 \quad (\text{homework}) \\ & x_1 + x_2 + x_3 = 1 \quad (\text{intermed. mktg.}) \\ & x_4 + x_5 + x_6 + x_7 \geq 1 \quad (\text{mktg. elective}) \\ & x_8 + x_9 + x_{10} \geq 1 \quad (\text{general elective}) \\ & x_1 + x_6 \leq 1 \quad (\text{MW 10:30}) \\ & x_2 + x_{10} \leq 1 \quad (\text{MW 1:30}) \\ & x_3 + x_4 \leq 1 \quad (\text{MW 3:00}) \\ & x_5 + x_8 \leq 1 \quad (\text{TTh 10:30}) \\ & x_1, \dots, x_{10} \in \{0, 1\} \end{array}$$

## 6 Hiring consultants

$x_i = 1$  if we hire the  $i^{\text{th}}$  consultant in the list, else 0 ( $i = 1, \dots, 6$ ).

$$\begin{array}{ll} \min & 250x_1 + 150x_2 + \dots + 190x_6 \\ \text{ST} & 3 \leq x_1 + \dots + x_6 \leq 5 \quad (\text{panel size}) \\ & x_1 + x_2 + x_3 \geq 1 \quad (\text{computer systems}) \\ & x_1 + x_4 + x_5 + x_6 \geq 1 \quad (\text{management}) \\ & x_2 + x_5 + x_6 \geq 1 \quad (\text{operations analysis}) \\ & x_1 + x_4 + x_6 \geq 2 \quad (\text{marketing}) \\ & x_5 + x_6 \leq 1 \quad (\text{Max and Sarah}) \\ & x_1, \dots, x_6 \in \{0, 1\} \end{array}$$

## 7 Planning an advertising campaign

(a) B25 = SUM(B20:B24)

(b) B28 = B3\*SUMPRODUCT(A20:A24,B20:B24)

(c)  $B29 = \text{SUMPRODUCT}(B8:B12, B20:B24)$

(d)  $B32 = D16 * \text{SUM}(B29:G29)$

$B33 = \text{SUM}(B28:G28)$

$B34 = C16 * \text{SUM}(B29:G29)$

$B35 = B32 - B33 - B34$

(e) Target = B35, maximize

B20:G24 binary

B25:G25  $\leq 1$

B33  $\leq A16$

Assume nonnegative may be checked but isn't necessary

Assume linear model

Tolerance = 0.5