Quiz Business Modeling

1. Consider the constraint
   \[ X_3 + X_4 + X_5 + X_6 + X_7 \geq 27 \]
   representing Air Express’ Monday worker requirement. Why was a “\( \geq \)” used versus an “\( = \)”?
   a. The “\( \geq \)” is needed to accommodate workers held over from Sunday.
   b. Solver only accepts “\( \geq \)” constraints.
   c. The “\( \geq \)” is less restrictive.
   d. The “\( = \)” will always produce an infeasible constraint.

2. A company wants to select no more than 2 projects from a set of 4 possible projects. Which of the following constraints ensures that no more than 2 will be selected.
   a. \( X_1 + X_2 + X_3 + X_4 = 2 \)
   b. \( X_1 + X_2 + X_3 + X_4 \leq 2 \)
   c. \( X_1 + X_2 + X_3 + X_4 \geq 2 \)
   d. \( X_1 + X_2 + X_3 + X_4 \geq 0 \)

3. A company wants to select 1 project from a set of 4 possible projects. Which of the following constraints ensures that only 1 will be selected.
   a. \( X_1 + X_2 + X_3 + X_4 = 1 \)
   b. \( X_1 + X_2 + X_3 + X_4 \leq 1 \)
   c. \( X_1 + X_2 + X_3 + X_4 \geq 1 \)
   d. \( X_1 + X_2 + X_3 + X_4 \geq 0 \)

4. If a company produces Product 1, then it must produce at least 150 units of Product 1. Which of the following constraints enforce this condition?
   a. \( X_1 \leq 150Y_1 \)
   b. \( X_1 - 150Y_1 \geq 0 \)
   c. \( X_1Y_1 \leq 150 \)
   d. \( X_1 \geq 150 + Y_1 \)

5. A production company wants to ensure that if Product 1 is produced, production of Product 1 not exceed production of Product 2. Which of the following constraints enforce this condition?
   a. \( X_1 \geq M_2Y_2 \)
   b. \( X_1 \leq M_2X_2 \)
   c. \( X_1 \leq M_1Y_1 \), \( X_1 \leq Y_1X_2 \)
   d. \( X_1 \leq X_2 \)

6. A company must invest in project 1 in order to invest in project 2. Which of the following constraints ensures that project 1 will be chosen if project 2 is invested in?
   a. \( X_1 + X_2 = 0 \)
   b. \( X_1 + X_2 = 1 \)
   c. \( X_1 - X_2 \geq 0 \)
   d. \( X_1 - X_2 \leq 0 \)

7. If a company selects Project 1 then it must also select either Project 2 or Project 3. Which of the following constraints enforce this condition?
   a. \( X_1 - X_2 - X_3 \geq 0 \)
   b. \( X_1 + (X_2 - X_3) \leq 0 \)
   c. \( X_1 + X_2 + X_3 \leq 2 \)
   d. \( X_1 - X_2 - X_3 \leq 0 \)

8. If a company selects either of Project 1 or Project 2 (or both), then either Project 3 or Project 4 (or both) must also be selected. Which of the following constraints enforce this condition?
   a. \( X_1 + X_2 \leq 2(X_3 + X_4) \)
   b. \( X_1 + X_2 \leq X_3 + X_4 \)
   c. \( X_1 - X_3 = X_2 - X_4 \)

d. \( X_1 + X_2 + X_3 + X_4 \leq 2 \)

9. A company is developing its weekly production plan. The company produces two products, A and B, which are processed in two departments. Setting up each batch of A requires $60 of labor while setting up a batch of B costs $80. Each unit of A generates a profit of $17 while a unit of B earns a profit of $21. The company can sell all the units it produces. The data for the problem are summarized below.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Hours required by</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
<td>3 4</td>
<td>48</td>
</tr>
<tr>
<td>Welding</td>
<td>2 1</td>
<td>36</td>
</tr>
</tbody>
</table>

The decision variables are defined as

\[ X_i = \text{the amount of product } i \text{ produced} \]
\[ Y_i = 1 \text{ if } X_i > 0 \text{ and } 0 \text{ if } X_i = 0 \]

What is the objective function for this problem?

a. MAX: \( 17 X_1 + 21 X_2 \)
b. MAX: \( 17 X_1 + 21 X_2 - 60 Y_1 - 80 Y_2 \)
c. MIN: \( 17 X_1 + 21 X_2 - 60 Y_1 - 80 Y_2 \)
d. MIN: \( 60 Y_1 + 80 Y_2 \)

10. A company is developing its weekly production plan. The company produces two products, A and B, which are processed in two departments. Setting up each batch of A requires $60 of labor while setting up a batch of B costs $80. Each unit of A generates a profit of $17 while a unit of B earns a profit of $21. The company can sell all the units it produces. The data for the problem are summarized below.

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</thead>
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<td>48</td>
</tr>
<tr>
<td>Welding</td>
<td>2 1</td>
<td>36</td>
</tr>
</tbody>
</table>

The decision variables are defined as

\[ X_i = \text{the amount of product } i \text{ produced} \]
\[ Y_i = 1 \text{ if } X_i > 0 \text{ and } 0 \text{ if } X_i = 0 \]

Which of the following constraints creates the link between setting up to produce A’s and making some A’s for this problem?

a. \( X_1 \leq 16 Y_1 \)
b. \( X_1 - Y_1 = 0 \)
c. \( X_1 - 18 Y_1 > 0 \)
d. =if\((X_1 > 0, Y_1 = 1, Y_1 = 0)\)

11. A company is developing its weekly production plan. The company produces two products, A and B, which are processed in two departments. Setting up each batch of A requires $60 of labor while setting up a batch of B costs $80. Each unit of A generates a profit of $17 while a unit of B earns a profit of $21. The company can sell all the units it produces. The data for the problem are summarized below.

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</tr>
<tr>
<td>Welding</td>
<td>2 1</td>
<td>36</td>
</tr>
</tbody>
</table>

The decision variables are defined as
\(X_i = \) the amount of product \(i\) produced

\(Y_i = 1\) if \(X_i > 0\) and \(0\) if \(X_i = 0\)

What is the appropriate value for \(M_1\) in the linking constraint for product \(A\)?

a. 2
b. 3
c. 16
d. 18

12. A company is developing its weekly production plan. The company produces two products, \(A\) and \(B\), which are processed in two departments. Setting up each batch of \(A\) requires $60 of labor while setting up a batch of \(B\) costs $80. Each unit of \(A\) generates a profit of $17 while a unit of \(B\) earns a profit of $21. The company can sell all the units it produces. The data for the problem are summarized below.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Hours required by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(A)</td>
</tr>
<tr>
<td>Cutting</td>
<td>3</td>
</tr>
<tr>
<td>Welding</td>
<td>2</td>
</tr>
</tbody>
</table>

What is the appropriate formula to use in cell \(E8\) of the following Excel implementation of the ILP model for this problem?

a. \(\text{SUMPRODUCT}(B5:C5,B7:C7) - \text{SUMPRODUCT}(B8:C8,B14:C14)\)
b. \(\text{SUMPRODUCT}(B8:C8,B14:C14) - \text{SUMPRODUCT}(B5:C5,B7:C7)\)
c. \(\text{SUMPRODUCT}(B5:C5,B7:C7) - B8:C8\)
d. \(\text{SUMPRODUCT}(B5:C5,B7:C7) - \text{SUMPRODUCT}(B8:C8,B15:C15)\)
13. A company is developing its weekly production plan. The company produces two products, A and B, which are processed in two departments. Setting up each batch of A requires $60 of labor while setting up a batch of B costs $80. Each unit of A generates a profit of $17 while a unit of B earns a profit of $21. The company can sell all the units it produces. The data for the problem are summarized below.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Hours required by</th>
<th>A</th>
<th>B</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
<td></td>
<td>3</td>
<td>4</td>
<td>48</td>
</tr>
<tr>
<td>Welding</td>
<td></td>
<td>2</td>
<td>1</td>
<td>36</td>
</tr>
</tbody>
</table>

What is the appropriate formula to use in cell B15 of the following Excel implementation of the ILP model for this problem?

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>Fixed charge problem</td>
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<td>3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Product A</td>
<td>Product B</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>Number to produce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>Unit profit</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>Fixed cost</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>Resources</td>
<td>Hours required</td>
<td>Used</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>Cutting</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>Welding</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td>Binary variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>Linking constraints</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. = B5 - MIN($E$11/B11, $E$11/C11)*B14  
b. =B5 - MIN($E$11/B11, $E$12/B12)  
c. =B5 - $E$12/B12*B14  
d. =B5 - MIN($E$11/B11, $E$12/B12)*B14

14. A company is planning next month’s production. It has to pay a setup cost to produce a batch of X₄’s so if it does produce a batch it wants to produce at least 100 units. Which of the following pair of constraints shows the relationship(s) between the setup variable Y₄ and the production quantity variable X₄?

a. X₄ ≤ M₄Y₄, X₄ ≥ 100  
b. X₄ ≤ M₄Y₄, X₄ = 100 Y₄  
c. X₄ ≤ M₄Y₄, X₄ ≥ 100 Y₄  
d. X₄ ≤ M₄Y₄, X₄ ≤ 100 Y₄

15. A company will be able to obtain a quantity discount on component parts for its three products, X₁, X₂ and X₃ if it produces beyond certain limits. To get the X₁ discount it must produce more than 50 X₁’s. It must produce more than 60
X_2's for the X_2 discount and 70 X_3's for the X_3 discount. How many binary variables are required in the formulation of this problem?

a. 3  
b. 6  
c. 9  
d. 12

16. A company will be able to obtain a quantity discount on component parts for its three products, X_1, X_2 and X_3 if it produces beyond certain limits. To get the X_1 discount it must produce more than 50 X_1's. It must produce more than 60 X_2's for the X_2 discount and 70 X_3's for the X_3 discount. How many decision variables are required in the formulation of this problem?

a. 3  
b. 6  
c. 9  
d. 12

17. A company will be able to obtain a quantity discount on component parts for its three products, X_1, X_2 and X_3 if it produces beyond certain limits. To get the X_1 discount it must produce more than 50 X_1's. It must produce more than 60 X_2's for the X_2 discount and 70 X_3's for the X_3 discount. Which of the following pair of constraints enforces the quantity discount relationship on X_3?

a. X_{31} \leq M_3Y_3, X_{32} \geq 50Y_3  
b. X_{31} \leq M_3Y_3, X_{31} \geq 50  
c. X_{32} \geq (1/50)X_{31}, X_{31} \leq 50  
d. X_{32} \leq M_3Y_3, X_{31} \geq 50Y_3

18. A wedding caterer has several wine shops from which it can order champagne. The caterer needs 100 bottles of champagne on a particular weekend for 2 weddings. The first supplier can supply either 40 bottles or 90 bottles. The relevant decision variable is defined as X_1 = the number of bottles supplied by supplier 1

Which set of constraints reflects the fact that supplier 1 can supply only 40 or 90 bottles?

a. X_1 \leq 40Y_{11}, X_1 \leq 90(1 - Y_{11})  
b. X_1 = 40Y_{11} + 90Y_{12}, Y_{11} + Y_{12} \leq 1  
c. X_1 = 40Y_{11} + 90(1 - Y_{11}), Y_{11} = 0 \text{ OR } 1  
d. X_1 = 40Y_{11} + 90Y_{12}, Y_{11} + Y_{12} = 1

The Questions 19 to 24 are based on the problem below.

UAM installs high pressurized instruments for small aircrafts. UAM is developing a 3-period production and inventory plan model based on the relevant information in the table below.

<table>
<thead>
<tr>
<th>Period</th>
<th>Production Cost ($)</th>
<th>Demand (Units)</th>
<th>Inventory Cost ($)</th>
<th>Regular Production Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.8</td>
<td>500</td>
<td>1</td>
<td>250</td>
</tr>
<tr>
<td>2</td>
<td>3.9</td>
<td>300</td>
<td>1.1</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>4.1</td>
<td>400</td>
<td>1.5</td>
<td>300</td>
</tr>
</tbody>
</table>

The beginning inventory for period 1 is 100 units. In addition, UAM would like to have at least 50 units in ending inventory for period 3. The ending inventory (t) = the beginning inventory (t) + production (t) - demand (t) in the same period (t).

4.1 Develop a linear programming model for UAM to minimize its total production and inventory cost:

19. Define Decision variables clearly:

a. P_1, P_2 and P_3
b. \( P_1, P_2, P_3, I_1, I_2 \) and \( I_3 \) for periods 1, 2 and 3, respectively.
c. \( P_1, P_2, P_3, I_1, I_2 \) and \( I_3 \) for periods 1, 2 and 3, respectively.
d. \( P_1, P_2, \) and \( P_3 \) the number of units to make in the periods 1, 2, and 3, respectively.

20. Write the objective function (with its goal):
   a. \( \text{MAX: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + \frac{1}{2} (100+I_1) + 1.1 (I_1 + I_2) + 1.5 (I_2 + I_3)/2 \)
   b. \( \text{MIN: } P_1 + P_2 + P_3 + \frac{1}{2} (100+I_1) + 1.1 (I_1 + I_2) + 1.5 (I_2 + I_3)/2 \)
   c. \( \text{MIN: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + I_1/2 + 1.1 (I_1 + I_2)/2 + 1.5 (I_2 + I_3)/2 \)
   d. \( \text{MIN: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + \frac{1}{2} (100+I_1) + 1.1 (I_1 + I_2) + 1.5 (I_2 + I_3)/2 \)

21. Identify which one of the following is NOT a constraint for the problem:
   a. \( I_3 = I_2 + P_3 - 400 \)
   b. \( 0 \leq P_3 \leq 300 \)
   c. \( P_1, P_2, P_3, I_1, I_2, \) and \( I_3 \geq 0 \)
   d. \( I_3 = 50 \)

22. The table below shows the selling prices per unit. UAM would like to maximize its total profit. Write out the objective function (with its goal):

<table>
<thead>
<tr>
<th>Period</th>
<th>Selling Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>15.5</td>
</tr>
</tbody>
</table>

a. \( \text{MIN: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + \frac{1}{2} (100+I_1) + 1.1 (I_1 + I_2) + 1.5 (I_2 + I_3)/2 \)

b. \( \text{MAX: } 15 \times 500 + 16 \times 300 + 15.5 \times 400 \)

c. \( \text{MAX: } 15 \times 500 + 16 \times 300 + 15.5 \times 400 - [P_1 + P_2 + P_3 + I_1/2 + 1.1 (I_1 + I_2)/2 + 1.5 (I_2 + I_3)/2] \)

d. \( \text{MAX: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + \frac{1}{2} (100+I_1) + 1.1 (I_1 + I_2) + 1.5 (I_2 + I_3)/2 \)

The Table below shows the overtime production capacity and cost of production in overtime. UAM would like to minimize the total production and inventory cost based on the additional information given in the Problem above.

<table>
<thead>
<tr>
<th>Period</th>
<th>Overtime Production Capacity</th>
<th>Overtime Production Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>6.4</td>
</tr>
<tr>
<td>3</td>
<td>125</td>
<td>6.8</td>
</tr>
</tbody>
</table>

23. Define additional decision variables used here?
   a. \( O_1, O_2 \) and \( O_3 \)
   b. \( O_1, O_2 \) and \( O_3 \) for periods 1, 2 and 3
   c. \( O_1, O_2 \) and \( O_3 \) = the overtimes in the periods 1, 2 and 3
   d. \( O_1, O_2 \) and \( O_3 \) = the number of units made in overtimes in the periods 1, 2 and 3.

24. Write out the objective function with its goal:
   a. \( \text{MIN: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + 6 O_1 + 6.4 O_2 + 6.8 O_3 + I_1 + (I_1 + I_2) + (I_2 + I_3) \)
   b. \( \text{MIN: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + O_1 + O_2 + O_3 + 1 (100+I_1)/2 + 1.1 (I_1 + I_2)/2 + 1.5 (I_2 + I_3)/2 \)
   c. \( \text{MAX: } P_1 + P_2 + P_3 + 6 O_1 + 6.4 O_2 + 6.8 O_3 + 1 (100+I_1)/2 + 1.1 (I_1 + I_2)/2 + 1.5 (I_2 + I_3)/2 \)
   d. \( \text{MIN: } 3.8 P_1 + 3.9 P_2 + 4.1 P_3 + 6 O_1 + 6.4 O_2 + 6.8 O_3 + 1 (100+I_1)/2 + 1.1 (I_1 + I_2)/2 + 1.5 (I_2 + I_3)/2 \)

25. Write out the constraints: Which one of the following is not a constraint here:
   a. \( I_1 = I_2 + P_3 - 400 \)
   b. \( 0 \leq P_3 \leq 300 \)
   c. \( O_3 \leq 125 \)
   d. \( 50 \leq O_3 \leq 100 \)