Table 1 Truth table.

x	y	z	$x+\overline{x}y+\overline{xy}z$	$x+y+z$
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	1	1
1	0	0	1	1
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

1.

a. CAPEX stands for Capital expenses, i.e. costs associated with the acquirement or upgrade of physical assets such as equipment, property or industrial buildings.

b. OPEX stands for Operating expenses, i.e., the ongoing costs for performing the production.

2.

a. A KPI is a measure of performance. Each KPI is a single number.

b. Downtime: Describes how large part of the time that a system has not been producing. Can indicate if there are reliability issues.

Yield: Describes how much product is obtained per raw material. Used to indicate how much waste there is in the production.

3. $\overline{x}$ can be removed from the second term since that term can only affect the value of the expression when x is false, otherwise the expression is always true. For the same reason, $\overline{xy}$ can now be removed from the third term which yields the right hand side.

Alternatively this can be shown with a truth table, see Table 1.

4.

a. The constraints can be formulated as

$$\begin{aligned} 1x_1 + 2x_2 &<= 22 \\ 12x_1 + 4x_2 &<= 96 \\ 5x_1 + 5x_2 &<= 60 \end{aligned}$$

where x_1 and x_2 is the production rate of Super and Nova respectively. With the additional constraints $x_1 >= 0$ and $x_2 >= 0$, the area of admissible solutions is given in Figure. 1. As can be seen, there are 5 vertexes where the optimal solution can be located. The five are given by

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 2 & 6 & 8 \\ 0 & 11 & 10 & 6 & 0 \end{bmatrix}$$

Given the prices $p_1 = 7$ and $p_2 = 4$, the revenue for the company in each vertex is

$$\begin{bmatrix} p_1 \\ p_2 \end{bmatrix}^T \begin{bmatrix} 0 & 0 & 2 & 6 & 8 \\ 0 & 11 & 10 & 6 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 44 & 54 & 66 & 56 \end{bmatrix}$$

The optimal production rate is consequently $x_1 = 6$ and $x_2 = 6$ and the revenue is 66.

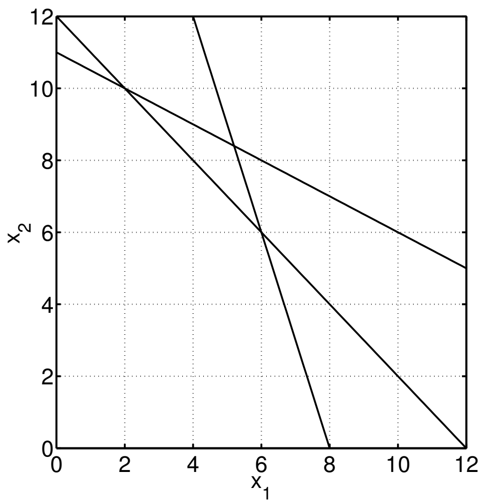

Figure 1 Admissible solutions

b. The intersection of the capacity limits of forming and bristling machine is at $x_1 = 5.2$ and $x_2 = 8.4$. This corresponds to a capacity usage of 68 in the packaging machine and it is consequently the minimum capacity level that can achieve this.

c. If the price p_1 is lowered, production will move from $x_1 = 6$ and $x_2 = 6$ to $x_1 = 2$ and $x_2 = 10$. The break-point can be formulated as

$$\begin{aligned} 6p_1 + 24 &= 2p_1 + 40 \\ p_1 &= 4 \end{aligned}$$

Hence, at 4, the company moves away from the original product mix. The revenue at that point is 48.

5.

a. Batch, the ICs are produced in batches.

b. The solution is shown in Figure 2.

6.

a. See lecture slides.

b. The area utility matrix becomes

$$Au = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}.$$

c. The utility operation matrix is

$$U = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 \end{bmatrix}$$

d. The direct loss J_p is calculated as

$$Jp = (1 - A_{av}^{Dir}) .* q_m .* p * n_s$$

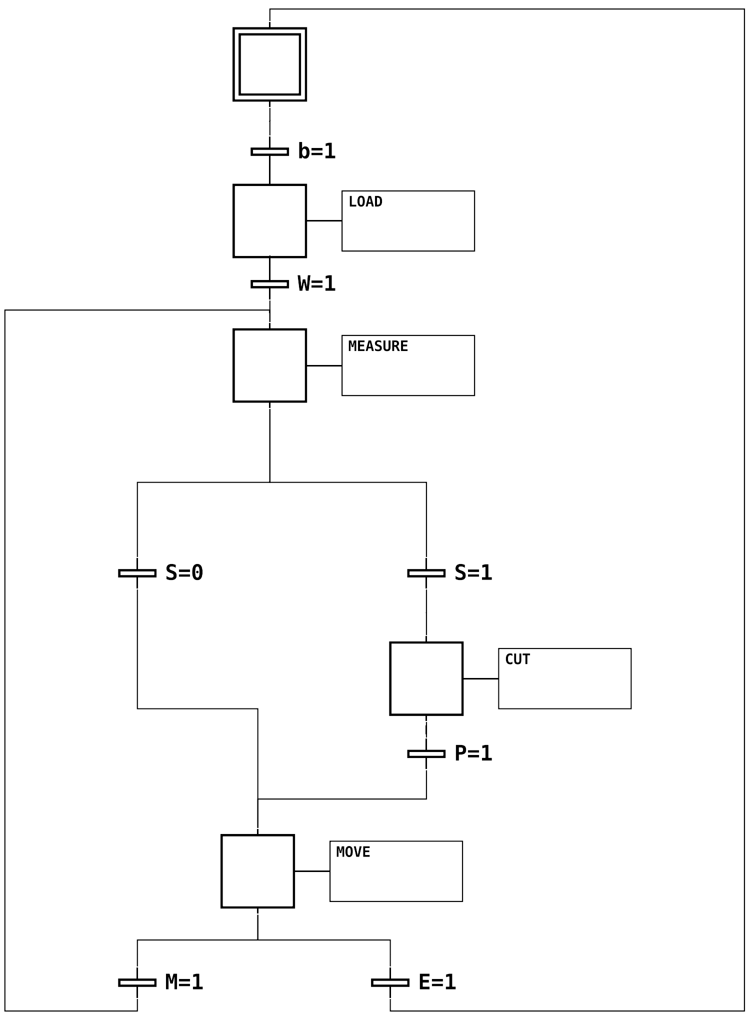

Figure 2 Solution to Problem 5

and becomes

$$Jp = [9 \quad 120 \quad 24 \quad 0 \quad 60]^T.$$

7.

a. The plant structure is drawn in Figure 3.

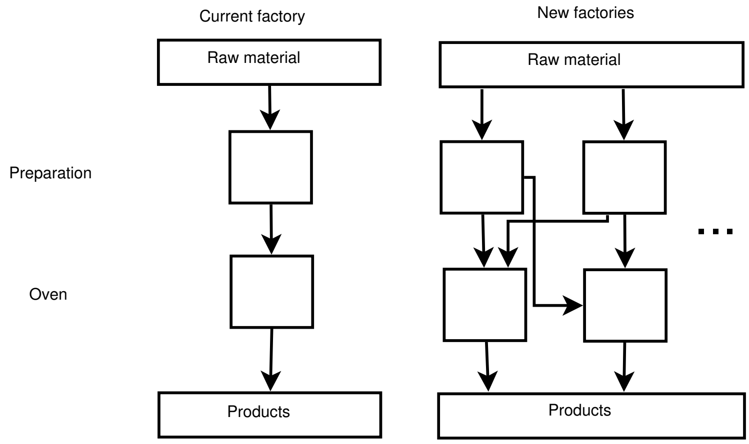

Figure 3

The current factory has a single-path structure. As the new factories have interconnected parallel processing and parallel ovens, they will have a network structure.

b. It is a master recipy.

General and site recipies do not have any information about the production equipment. A control recipies is a single execution instances of a master recipy.

8.

a. Optimization of the quadratic profit functions gives

$$\begin{aligned} B_1(Q_2) &= \max(0, 2 - c_1 - Q_2)/2 \\ B_2(Q_1) &= \max(0, 2 - c_2 - Q_1)/2. \end{aligned}$$

b. We need to find solutions to the simultaneous equations

$$\begin{aligned} Q_1^* &= \max(0, 2 - c_1 - Q_2^*)/2 \\ Q_2^* &= \max(0, 2 - c_2 - Q_1^*)/2. \end{aligned}$$

If we first assume that $Q_1^* = 0$ then the 2nd equation gives $Q_2^* = 1 - c_2/2$. Inserting this again in the 1st equation gives the condition $2 - c_1 - (1 - c_2/2) \leq 0$ which is equivalent to $2 - 2c_1 + c_2 \leq 0$. This describes the area in the (c_1, c_2) plane where $(Q_1^*, Q_2^*) = (0, 1 - c_2/2)$ holds, i.e. a monopoly situation for firm 2.

By symmetry we have $(Q_1^*, Q_2^*) = (1 - c_1/2, 0)$, i.e. monopoly for firm 1, in the area where $2 - 2c_2 + c_1 \leq 0$.

When both Q_1^* and Q_2^* are positive we have the equation system

$$\begin{aligned} Q_1^* &= (2 - c_1 - Q_2^*)/2 \\ Q_2^* &= (2 - c_2 - Q_1^*)/2. \end{aligned}$$

which has the solution $(Q_1^*, Q_2^*) = \left(\frac{2-2c_1+c_2}{3}, \frac{2-2c_2+c_1}{3}\right)$.

With a sufficiently large difference in manufacturing costs the duopoly market hence collapses into a monopoly.