Q1.
(a)

X_{ij} : amt added to site i, of Tier j

$i: 1, 2 \ldots 5$

$j:$ Tier 1, Tier 2, Tier 3.

$X_{ij} \geq 0 \quad \forall i, \forall j$

$X_{i1} \leq 5 y_{i1} \quad \forall i$

$5 y_{i2} \leq X_{i2} \leq 10 y_{i2} \quad \forall i$

$10 y_{i2} \leq X_{i3} \leq 15 y_{i2}$

$\min \quad \sum_{j=1}^{3} \sum_{i=1}^{5} X_{ij} C_{ij} + d_{ij} \cdot y_{ij}$

$y_{ij} \begin{cases} 1 & \text{if plan Tier } j \text{ is chosen for site } i \\ 0 \end{cases}$

$\sum_{j=1}^{3} X_{ij} \geq 30 y_{ij} \quad \forall i$

(c)

$C_{max} \geq 0$

$C_{max} \geq \sum_{j} \sum_{i} X_{ij} C_{ij} + d_{ij} \cdot y_{ij}$

obj: $\min \quad C_{max}.$

Q2: (a) $X_i = \begin{cases} 1 & \text{node included in clique or not} \\ 0 \end{cases}$

$$\max \sum X_i$$

$$X_i + X_j \le 1 \qquad \forall (i,j) \notin A$$
$$\text{where } i \ne j$$

$\begin{matrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{matrix}$

(c_2) (c)

$X_i + X_j = 2$

$Y_{iz} = \begin{cases} 1 & : \text{node } i \text{ part of zone } j \\ 0 \end{cases}$

$$\min \sum_i \sum_z Y_{iz} \, C_z$$

C_z Parameter $\to (i,z)$.

$Y_{iz} = 0 \quad \forall (i,z) \notin Arc$
$Y_{iz} \ge 0 \quad \forall (i,z) \in Arc$

$$\sum_{z=1}^{6} Y_{iz} = 1 \qquad \forall i \in N$$

A B
B A

Q3. (a) X_{ij} : amount of item i, using transport j

$y_i \begin{cases} 1 \\ 0 \end{cases}$ if penalty charged.

$$\min \sum_{j \in J} \sum_{i \in I} X_{ij} \, c_{ij} + \sum_{i \in I} y_i \, P_i$$

• demand :=

$$\sum_{j \in J} X_{ij} \geq D_i \quad \forall i$$

• Penalty :— $y_i \geq 0$, binary.

$$y_i \leq \left(t_i - \sum_{j \in J} X_{ij} \cdot S_{ij} \right)$$

$A \rightarrow$ -ve
$y = 0 \; \boxed{y \leq 0}$ or $^{+1}$

$A \rightarrow$ +ve
$\boxed{y \geq 1}$
$y = 1$

$y \geq 0$
$t_i \, (1)$

$y = 0 \rightarrow$
$y = 1 \; t_i \; <_{Mvo}$

$$t_i \leq \sum_{j \in J} X_{ij} S_{ij} + M(1 - y_i) \quad \forall i$$

$$\sum_{j \in J} X_{ij} S_{ij} \geq t_i + M(1 - y_i) \quad \forall i$$

(b) $z_{ij} : \begin{cases} 1 \\ 0 \end{cases}$ if item i transported by j

$$x_{ij} \geq z_{ij}$$

$$\underset{j \in J}{\angle} z_{ij} = 2 \quad \forall i$$

$x_{ij} \quad \forall i$

$x_{i1}, x_{i2},$
x_{i3}

② $> ,0,+$

z_{ij} ① if i
ships j

$\left(\angle_{j} z_{ij} = 2 \right) \forall i$

$z_{ij} \geq x_{ij}$
$x = 0, \; z = 0$

$\underset{0}{x} > 0, \; \underset{0}{z} = 1$
$\underset{x}{\downarrow} \geq \underset{z}{\downarrow}$

#4 Tax sites $i = 1, 2 \ldots 5$

(a) corporate Loc. $j = 1, 2, 3 \ldots = 8$

$(FC)_i$, $(C)_{ij}$

$x_{ij} :$ # of audits

$y_{ij} =$ if site i is used $\{0, 1\}$

$$obj \quad \omega \left[\sum_j \sum_i \left[(FC)_i + C_{ij} \right] x_{ij} \right] + \left[\sum_j \sum_i Q_{ij} \, x_{ij} \right] (1-\omega)$$

$$+ \sum_{i=1}^{5} (FC)_i \, y_i$$

$$\sum_{i=1}^{5} x_{ij} \geq (req)_j \qquad \forall j = 1, 2 \cdots 8$$

$y_i = 0$
$y_i = 1$

$$\sum_{j=1}^{8} x_{ij} \leq 0 + y_i \, M \qquad \forall i$$

Obj. min $\left[\sum_{j=1}^{8} \sum_{i=1}^{5} C_{ij} \, x_{ij} + \sum_{i=1}^{5} (FC)_i \, y_i \right] W$

$$- \left[\sum_{j=1}^{8} \sum_{i=1}^{5} Q_{ij} \, x_{ij} \right] (1-W)$$

(d) $T_c = 300$
      $T_q = 1700$

$\delta_c \rightarrow$ Penalty for cost

$\delta_q \rightarrow$ Penalty for quality

$$\delta_c = T_c - \sum_{j=1}^{8} \sum_{i=1}^{5} C_{ij} X_{ij} + \sum_{i=1}^{5} (FC)_i \, y_i$$

$$\delta_q = T_q - \sum_{j=1}^{8} \sum_{i=1}^{5} \vartheta_{ij} X_{ij}$$

<u>obj</u>$\rightarrow$ min $\delta_c W + \delta_q (1-W)$

∵ ∀ Rest constraints remains same.