# 1 Question3

## 1.1 Analysis

In order to have a more accurate indoor temperature discrete model, we want the finest coefficient of $a_1, a_2, a_3$. We can achieve that by minimizing the square of the error between real $T_{b,k+1}$ and estimation.
From 2.1.2, we can rewrite the formula:

$$\sum_{i=1}^{N} \{[(T_{b,k+1} - T_{b,K}) - \Delta t(a_1 \dot{q_{solar,k}} + a_2(\dot{q_{occ,k}} + \dot{q_{ac,k}} - \dot{q_{vent,k}}) + a_3(T_{amb,k} - T_{b,k})]\} \tag{1}$$

We set:

$$\begin{aligned}
T &= (T_{b,k+1} - T_{b,K}) \\
(\dot{q_{occ,k}} + \dot{q_{ac,k}} - \dot{q_{vent,k}}) &= (\dot{q_{sigma,k}}) \\
T_{amb,k} - T_{b,k} &= T_{sigma,k} \\
(a_1 \dot{q_{solar,k}} + a_2(\dot{q_{sigma,k}}) + a_3(T_{sigma,k}) &= \begin{bmatrix} \dot{q_{solar,k}} & \dot{q_{sigma,k}} & \dot{T_{sigma,k}} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} \\
\begin{bmatrix} \dot{q_{solar,k}} & \dot{q_{sigma,k}} & \dot{T_{sigma,k}} \end{bmatrix} &= \begin{bmatrix} \dot{q_k} \end{bmatrix} \\
\begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} &= \begin{bmatrix} a \end{bmatrix}
\end{aligned} \tag{2}$$

We can rewrite (1) to:

$$\begin{aligned}
&\begin{bmatrix} T - \begin{bmatrix} \dot{q} \end{bmatrix} \begin{bmatrix} a \end{bmatrix} \end{bmatrix}^T \begin{bmatrix} T - \begin{bmatrix} \dot{q} \end{bmatrix} \begin{bmatrix} a \end{bmatrix} \end{bmatrix} \\
&= a^T \dot{q}^T \dot{q} a - 2T^T \dot{q} a + T^T T
\end{aligned} \tag{3}$$

## 1.2 Model

This is a quadratic programming problem, standard form of a quadratic programming is:

$$\begin{aligned}
\min_x \quad & \frac{1}{2} x^T H x + c^T x \\
Ax &= b \\
x &\geq 0
\end{aligned} \tag{4}$$

For formula (5), it is a standard form of quadratic programming problem, where:

$$\begin{aligned}
H &= 2\dot{q}^T \dot{q} \\
c^T &= 2T^T \dot{q}
\end{aligned} \tag{5}$$

## 1.3 solution

We can use function in MATLAB to solve it. Details of each matrix are store in MATLAB, as a result, we only show final result here:

$$
\begin{aligned}
a_1 &= 2.662 \times 10^{-6} \\
a_2 &= 1.056 \times 10^{-6} \\
a_3 &= 2.135 \times 10^{-6}
\end{aligned} \tag{6}
$$