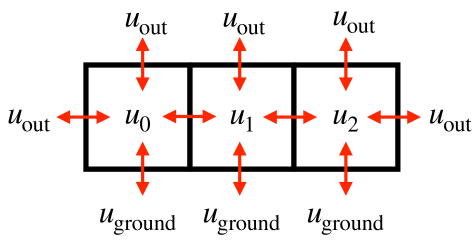
Previous Next

3.3.1 Finger Exercise: Wreaking HVAC with matrices

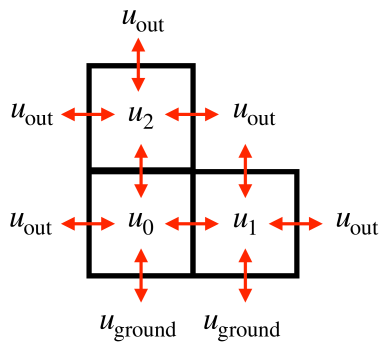
Finger Exercises 2 due Aug 10, 2023 05:00 IST Completed

MO2.8

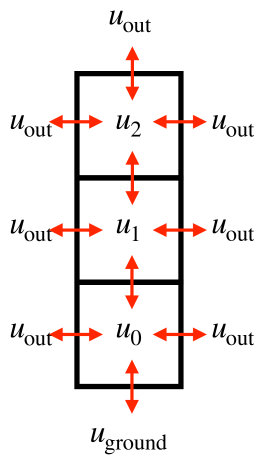
Apply the building heating analysis, considering the following three configurations of a three room house:



Unilevel



Bilevel



Trilevel

The temperatures in rooms 0, 1, and 2 are denoted u_0, u_1, and u_2, respectively. Each room has six sides: left, right, front, back, top, and bottom. Note that the front and back sides are not shown in the figure, and that these walls are always to the exterior air (u_{out}). Heat transfer occurs through all six sides of each room. In some cases, the heat transfer is between the rooms. In other cases, the heat transfer is between a room and the exterior air (with temperature u_{out}) or between a room and the ground (with temperature u_{ground}).

Assuming that the properties of the rooms (m_{room} and c_c) and the sides (h_{side} and A_{side}) are all the same, then the governing equations for the time rate of change of a room's temperature due to the heat transfer through each side of the room can be written,

$$\frac{\mathrm{d}u_{\text{room}}}{\mathrm{d}t} = k\Delta u_{\text{left}} + k\Delta u_{\text{right}} + k\Delta u_{\text{front}} + k\Delta u_{\text{back}} + k\Delta u_{\text{top}} + k\Delta u_{\text{bot}} \tag{3.10}$$

where k is a positive constant equal to $h_{\text{side}} A_{\text{side}} / \left(m_{\text{room}} c_c\right)$, and the Δu's are the temperature differences across the six sides of the room relative to the room temperature. Specifically:

$$\Delta u_{\text{left}} = u_{\text{left}} - u_{\text{room}} \tag{3.11}$$

$$\Delta u_{\text{right}} = u_{\text{right}} - u_{\text{room}} \tag{3.12}$$

$$\Delta u_{\text{front}} = u_{\text{front}} - u_{\text{room}} \tag{3.13}$$

$$\Delta u_{\text{back}} = u_{\text{back}} - u_{\text{room}} \tag{3.14}$$

$$\Delta u_{\text{top}} = u_{\text{top}} - u_{\text{room}} \tag{3.15}$$

$$\Delta u_{\text{bot}} = u_{\text{bot}} - u_{\text{room}} \tag{3.16}$$

Here are some examples,

- Consider the time rate of change for the temperature of room 1 for a configuration in which the exterior air was outside the left wall of room 1, then $u_{\text{room}} = u_1$, $u_{\text{left}} = u_{\text{out}}$ and $\Delta u_{\text{left}} = u_{\text{out}} - u_1$.

Discussions

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Problem Explanation I'm hav
bennettbashir100
3

- Consider the time rate of change for the temperature of room 0 for a configuration in which room 2 was above room 0, then $u_{\mathrm{room}} = u_0$, $u_{\mathrm{top}} = u_2$ and $\Delta u_{\mathrm{top}} = u_2 - u_0$.

- Since the front and back always are exterior walls to the outside air, then $u_{\mathrm{front}} = u_{\mathrm{out}}$ and $u_{\mathrm{back}} = u_{\mathrm{out}}$.

Applying these assumptions to the house configurations above will result in a model system of equations of the following form:

$$\frac{\mathrm{d}\underline{u}}{\mathrm{d}t} = kA\underline{u} + \underline{b} \tag{3.17}$$

In the questions below, use the following notation for the elements of the A matrix:

$$A = \begin{bmatrix} A_{00} & A_{01} & A_{02} \\ A_{10} & A_{11} & A_{12} \\ A_{20} & A_{21} & A_{22} \end{bmatrix} \tag{3.18}$$

Problem: Unilevel home

2.0/2.0 points (graded)
For the unilevel home:

What is the value of A_{00}?

-6 ✔ Answer: -6

What is the value of A_{01}?

1 ✔ Answer: 1

What is the value of A_{02}?

0 ✔ Answer: 0

What is the value of A_{10}?

1 ✔ Answer: 1

What is the value of A_{11}?

-6 ✔ Answer: -6

What is the value of A_{12}?

1 ✔ Answer: 1

What is the value of A_{20}?

Previous Next

What is the value of A_{11}?

-6 ✔ Answer: -6

What is the value of A_{12}?

0 ✔ Answer: 0

What is the value of A_{20}?

1

✔ Answer: 1

What is the value of A_{21}?

0

✔ Answer: 0

What is the value of A_{22}?

-6

✔ Answer: -6

Submit

Answers are displayed within the problem

Problem: Trilevel home

2.0/2.0 points (graded)

For the trilevel home:

What is the value of A_{00}?

-6

✔ Answer: -6

What is the value of A_{01}?

1

✔ Answer: 1

What is the value of A_{02}?

0

✔ Answer: 0

What is the value of A_{10}?

1

✔ Answer: 1

What is the value of A_{11}?

-6

✔ Answer: -6

What is the value of A_{12}?

1

✔ Answer: 1

What is the value of A_{20}?

0

✔ Answer: 0

What is the value of A_{21}?

1

✔ Answer: 1

What is the value of A_{22}?

-6

✔ Answer: -6

Submit