< Previous Next >

4.2.4 Problem Set: Welcome to SlimTown

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SlimTown is an iconic college town, known not only for its outstanding university but also because the architecture in the town is decreed to be slim; specifically, a building can only have one room through its depth. A cold front recently came through SlimTown and dropped the somewhat cold temperature from 5° C to -10° C. In this part of the problem set, we will study the impact of this cold front on Slimmons, one of the iconic residence halls at the university, which is shown in Figure 4.9.

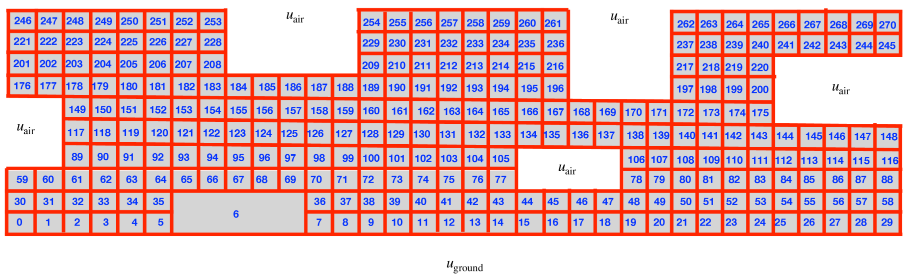

Figure 4.9: Slimmons residence hall

As we described in the course, heat transfer analysis of a building can be modeled using an IVP governed by a linear system of the form,

$$\frac{\mathrm{d}\underline{u}}{\mathrm{d}t} = A\underline{u} + \underline{b}(t) \tag{4.35}$$

And, the equilibrum condition for this system is the steady-state solution to this equation when $\underline{b}(t)$ does not vary in time. Specifically, the equilibrium condition is,

$$A\underline{u}_{\mathrm{eq}} + \underline{b}_{\mathrm{eq}} = 0 \Rightarrow A\underline{u}_{\mathrm{eq}} = -\underline{b}_{\mathrm{eq}} \tag{4.36}$$

For the heat transfer analysis of a building, that state will be the temperatures in each room. Slimmons has 271 rooms and thus the state vector $\underline{u}$ has a length $M = 271$. And further, A is an $M \times M = 271 \times 271$ matrix and b_{eq} is a vector of length $M = 271$.

The provided `solve_slimmons.py` code solves for the equilibrum temperature condition for Slimmons resulting from the cold front. The code uses the NumPy linear solver `np.linalg.solve` and a non-vectorized implementation of Gaussian elimination (which is in `mylinsolver.myGE`). You should observe that `np.linalg.solve` is significantly faster than `mylinsolver.myGE`. Running `solve_slimmons.py` will also plot the equilibrium temperature distribution. And, it will compare the equilibrium solution from `np.linalg.solve` and `mylinsolver.myGE`. Since these should be the same except for machine

< Previous Next >

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