

# Numerical Linear Algebra Assignment 18

## Exercise 1. (10 points)

Consider the FD system  $\mathbf{A}_h \mathbf{u}^h = \mathbf{f}^h$  on the fine grid, i.e.,

$$\frac{1}{h^2} \begin{bmatrix} 2 & -1 & & & \\ -1 & 2 & -1 & & \\ & \ddots & \ddots & \ddots & \\ & & -1 & 2 & -1 \\ & & & -1 & 2 \end{bmatrix} \begin{bmatrix} u_1^h \\ u_2^h \\ \vdots \\ u_{n-1}^h \\ u_n^h \end{bmatrix} = \begin{bmatrix} f_1^h \\ f_2^h \\ \vdots \\ f_{n-1}^h \\ f_n^h \end{bmatrix}.$$

Let  $H = 2h$  and define

$$\mathbf{I}_H^h = \frac{1}{2} \begin{bmatrix} 2 & & & & \\ 1 & 1 & & & \\ & 2 & & & \\ 1 & 1 & & & \\ \vdots & \vdots & & & \\ & & 1 & 1 & \\ & & & 2 \end{bmatrix}, \quad \mathbf{I}_h^H = \frac{1}{4} \begin{bmatrix} 2 & 1 & & & & \\ & 1 & 2 & 1 & \cdots & \\ & & & 1 & \cdots & \\ & & & & 1 & \\ & & & & 1 & 2 \end{bmatrix}.$$

Let  $\mathbf{A}_H$  be the FD discretization matrix on the coarse grid. What is the connection among  $\mathbf{I}_H^h$ ,  $\mathbf{I}_h^H$ ,  $\mathbf{A}_H$ , and  $\mathbf{A}_h$ ?

## Exercise 2. (10 points)

Prove Lemma 1 of Lecture 18.

## Exercise 3. (10 points)

Prove Proposition 2 of Lecture 18.

## Exercise 4. (10 points)

Prove Theorem 3 of Lecture 18.

**Compulsory requirement for programming: Use Matlab's publish to save all your code, comments, and results to a PDF file. You must use the programming format files: example\_format.zip.**

## Programming 1. (10 points)

Write matlab codes to verify your conclusion in Exercise 1.