# Simulation and Scientific Computing

### Assignment 3

# Conjugate Gradient Method with MPI parallelization

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### Theoretical Part:

a) Time taken for data transfer is given by,

Transfer time = 
$$\alpha$$
 + ( $\kappa/\beta$ )

Where  $\alpha$  – Latency for one transfer.

 $\kappa$  - number of elements exchanged between two neighbor processes in one transfer.

 $\beta$ - Bandwidth for transfer between two neighbor processes.

Considering there are k elements to be transferred, there will be k-1 elements to be transferred after 1<sup>st</sup> element transfer and with X being the compute time for update of one element the computation time for n elements can be given by,

$$c.t = (k.(k-1)/2) * X (sec)$$

The total time for n iterations per process can be given by,

Total time = Computation time + Transfer time  
= 
$$\alpha + (\kappa/\beta) + (k.(k-1)/2) * X (sec)$$

The time taken per iteration per process can be determined by,

$$T = (\alpha/k) + (1/\beta) + ((k-1)/2 * X)$$
 (sec)

b) To obtain k, we must minimize T, i.e. derivative of T with respect to k must be zero.

$$\partial T/\partial k = 0$$

Differentiating the above equation gives us,

$$K^2 = 2 \alpha / X$$

Substituting  $\alpha$  = 2ms and X = 0.2 m/s, K is obtained as 4.47  $\approx$  4.

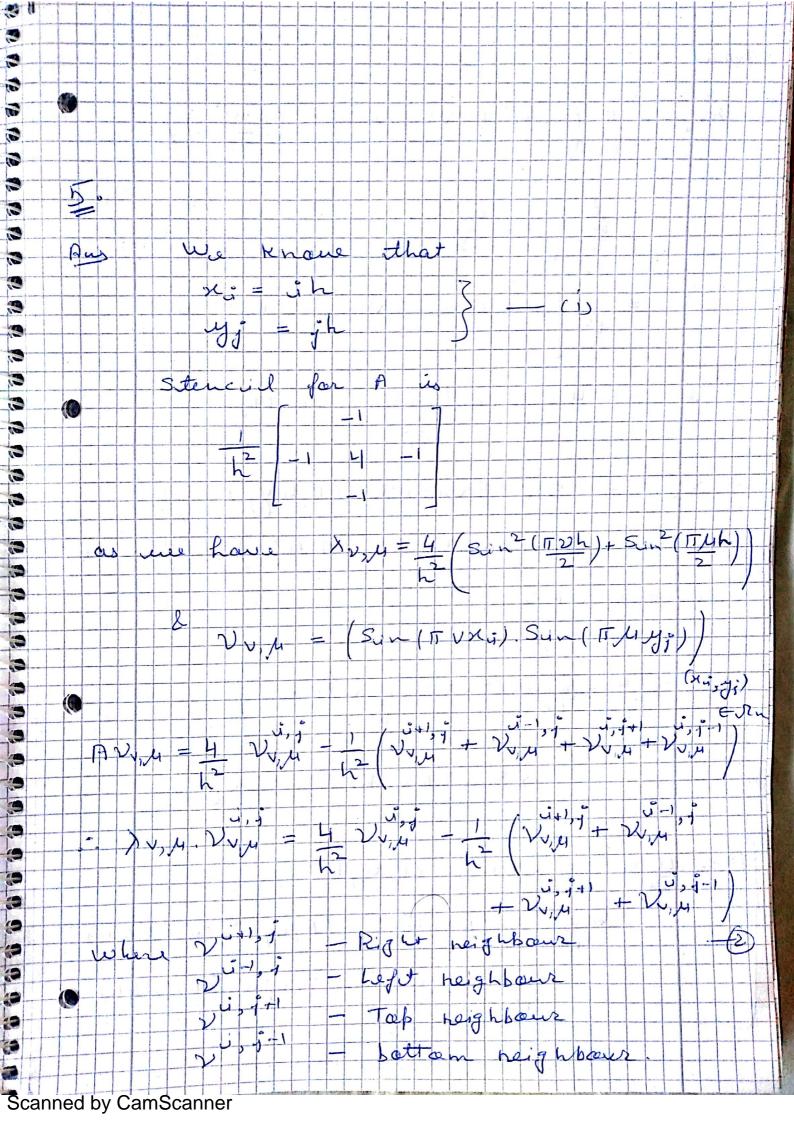
The value of K = 4 is the best value that minimizes the parallel overhead.

The overhead for the fictional setup,

 $\alpha$  = 2ms, X = 0.2 ms, and  $\beta$  = 30 elements/ms is calculated to be,

$$T = (\alpha/k) + (1/\beta) + ((k-1)/2 * X)$$
 (sec)

$$T = (2/4) + (1/30) + (3/2) *0.2 = 0.833 \text{ ms}$$



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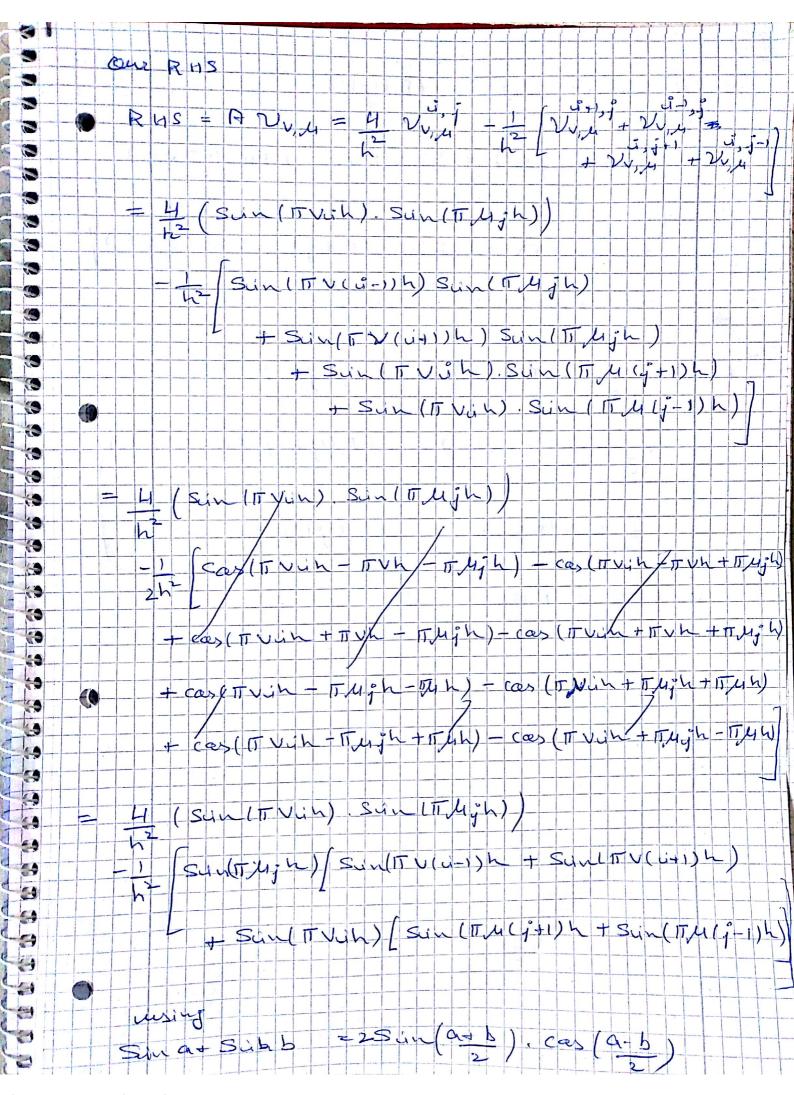
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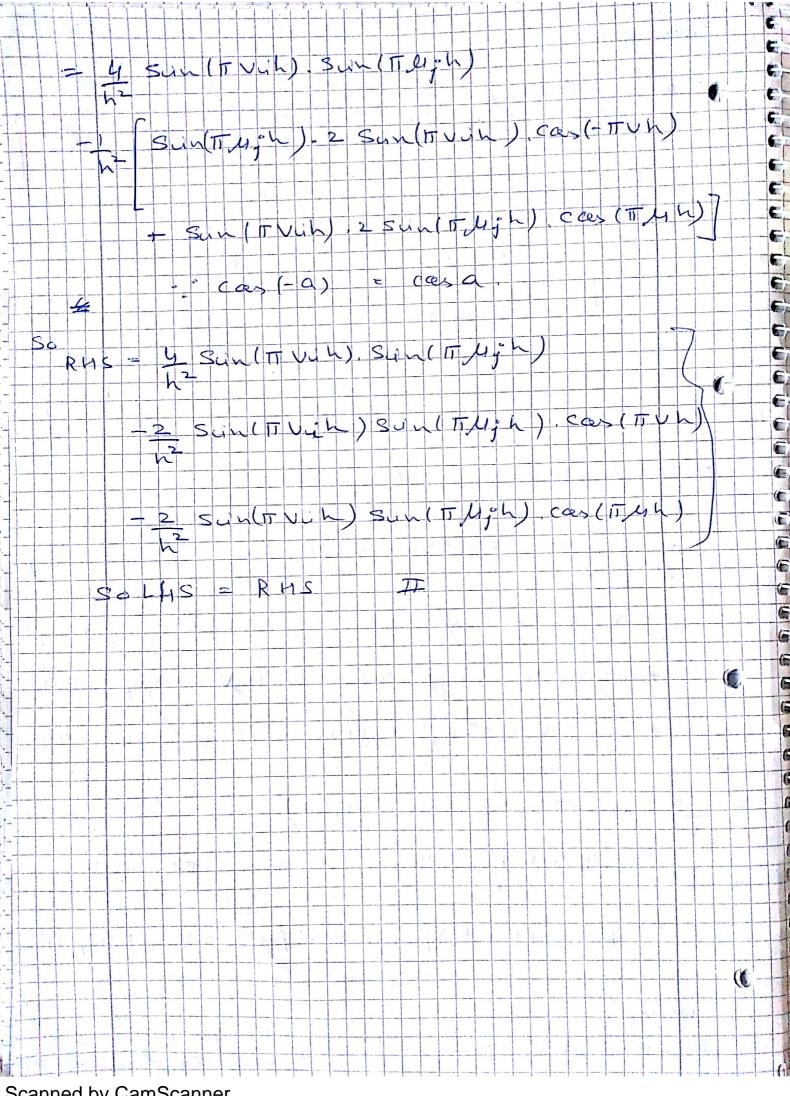
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