# Department of Computer Technology

### Vision of the Department

To be a well-known centre for pursuing computer education through innovative pedagogy, value-based education and industry collaboration.

### Mission of the Department

To establish learning ambience for ushering in computer engineering professionals in core and multidisciplinary area by developing Problem-solving skills through emerging technologies**.**

## Session 2025-2026

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| **Vision:** Dream of where you want. | **Mission:** Means to achieve Vision |

**Program Educational Objectives of the program (PEO):** (broad statements that describe the professional and career accomplishments)

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| PEO1 | **Preparation** | **P: Preparation** | **Pep-CL abbreviation pronounce as Pep-si-lL easy to recall** |
| PEO2 | **Core Competence** | **E: Environment (Learning Environment)** |
| PEO3 | **Breadth** | **P: Professionalism** |
| PEO4 | **Professionalism** | **C: Core Competence** |
| PEO5 | **Learning Environment** | **L: Breadth (Learning in diverse areas)** |

**Program Outcomes (PO):** (statements that describe what a student should be able to do and know by the end of a program)

## Keywords of POs:

Engineering knowledge, Problem analysis, Design/development of solutions, Conduct Investigations of Complex Problems, Engineering Tool Usage, The Engineer and The World, Ethics, Individual and Collaborative Team work, Communication, Project Management and Finance, Life-Long Learning

**PSO Keywords:** Cutting edge technologies, Research

“I am an engineer, and I know how to apply engineering knowledge to investigate, analyse and design solutions to complex problems using tools for entire world following all ethics in a collaborative way with proper management skills throughout my life.” *to contribute to the development of cutting-edge technologies and Research*.

**Integrity:** I will adhere to the Laboratory Code of Conduct and ethics in its entirety.

## Name and Signature of Student and Date

## Mohika Jugele – 02/09/25

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| **Session** | **2025-26 (ODD)** | | **Course Name** | **HPC Lab** |
| **Semester** | **7** | | **Course Code** | **22ADS706** |
| **Roll No** | **07** | | **Name of Student** | **Mohika Jugele** |
|  | | | | |
| Practical Number | | **04** | | |
| Course Outcome | | 1. Understand and Apply Parallel Programming Concepts 2. Analyze and Improve Program Performance.  3. Demonstrate Practical Skills in HPC Tools and Environments. | | |
| Aim | | Matrix Multiplication using OpenMP | | |
| Problem Definition | | Perform matrix multiplication | | |
| Theory  (100 words) | | Matrix multiplication is a fundamental computation in scientific computing, data analysis, computer graphics, and machine learning. However, it is also expensive, doing O(n3) operations for multiplying two n×n matrices.  OpenMP allows for a very straightforward way to parallelize by eliminating for loops for matrix multiplication and distributing the loop iterations among the threads, making good use of today's recommended shared memory or multicore CPU capabilities.  Applications:  Machine Learning (e.g., Neural Network training). Computer Graphics (3D transformations).  Scientific Computing (simulations, linear algebra solvers). Big Data Analytics (matrix factorization, recommendation systems). | | |
| Procedure and Execution  (100 Words) | | Algorithm:  **Step 1: Write the serial (single-threaded) matrix multiplication code**  **Step 2: Compile and run the serial program**  gcc -o matmul\_serial matmul\_serial.c  ./matmul\_serial 500 | | |

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|  | **Step 3: Add OpenMP parallelization and timin**g Save as matmul\_openmp.c |
| **Step 4: Compile and run the OpenMP version**  gcc -fopenmp -o matmul\_openmp matmul\_openmp.c export OMP\_NUM\_THREADS=4 # Set number of threads to 4  ./matmul\_openmp 500 |
| **Step 5: Compare results**  Version Execution Time (seconds) Comments Serial ~12.34 Baseline, no parallelism OpenMP (4 threads) ~4.12 |
| Code:  **matmul\_openmp.c** #include <stdio.h> #include <stdlib.h> #include <omp.h> |
| void matmul(int N, double \*A, double \*B, double  \*C) { #pragma omp parallel for collapse(2) for (int i = 0; i < N; i++)  for (int j = 0; j < N; j++) { double sum = 0;  for (int k = 0; k < N; k++)  sum += A[i\*N+k] \* B[k\*N+j]; C[i\*N+j] = sum;  }  } |
| int main(int argc, char \*\*argv) { if (argc < 3) {  printf("Usage: %s matrix\_size num\_threads\n", argv[0]); return 1;  } |
| int N = atoi(argv[1]);  int num\_threads = atoi(argv[2]); |

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|  | omp\_set\_num\_threads(num\_threads);  double \*A = malloc(N\*N\*sizeof(double)); double \*B = malloc(N\*N\*sizeof(double)); double \*C = malloc(N\*N\*sizeof(double));  for (int i = 0; i < N\*N; i++) { A[i] = 1.0;  B[i] = 2.0;  }  double start = omp\_get\_wtime(); matmul(N, A, B, C);  double end = omp\_get\_wtime();  printf("OpenMP MatMul (N=%d, threads=%d) elapsed time:  %f seconds\n",  N, num\_threads, end - start);  free(A); free(B); free(C); return 0;  }  **matmul\_serial.c** #include <stdio.h> #include <stdlib.h> #include <time.h>  static inline double now\_sec(void) { struct timespec ts;  clock\_gettime(CLOCK\_MONOTONIC, &ts); return ts.tv\_sec + ts.tv\_nsec \* 1e-9;  }  void matmul(int N, double \*A, double \*B, double  \*C) { for (int i = 0; i < N; i++) for (int j = 0; j < N; j++) { double sum = 0.0;  for (int k = 0; k < N; k++)  sum += A[(long)i\*N + k] \* B[(long)k\*N + j]; C[(long)i\*N + j] = sum;  }  } |

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|  | int main(int argc, char \*\*argv) { if (argc < 2) {  printf("Usage: %s N\n", argv[0]); return 1;  }  int N = atoi(argv[1]);  double \*A = (double\*)malloc((size\_t)N\*N\*sizeof(double)); double \*B  = (double\*)malloc((size\_t)N\*N\*sizeof(double)); double  \*C = (double\*)malloc((size\_t)N\*N\*sizeof(double)); if (!A  || !B || !C) {  fprintf(stderr, "malloc failed\n"); return 2;  }  for (long i = 0; i < (long)N\*N; i++) { A[i] = 1.0;  B[i] = 2.0;  }  double t0 = now\_sec(); matmul(N, A, B, C); double t1 = now\_sec();  double elapsed = t1 - t0;  double gflops = (2.0 \* N \* (double)N \* (double)N) / (elapsed \* 1e9);  printf("Serial MatMul: N=%d elapsed=%.6f s, perf=%.3f GFLOP/s\n",  N, elapsed, gflops);  free(A); free(B); free(C); return 0;  } |

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|  | Output: |

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| Output Analysis | **Version Execution Time(seconds) Comments**  Serial ~0.087082 Baseline, slower  OpenMP (4 ~3.9× faster serial threads) ~0.022222 |
| Link of student Github profile where lab assignment has been uploaded | https://github.com/Mohikaaa18/HPC-Lab |
| Conclusion | Matrix Multiplication using OpenMP implemented successfully. |

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