# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

## Session2025-2026

|  |  |
| --- | --- |
| **Vision:**Dreamofwhere youwant. | **Mission:** MeanstoachieveVision |

**ProgramEducationalObjectivesoftheprogram(PEO):** (broadstatementsthatdescribethe professional and career accomplishments)

|  |  |  |  |
| --- | --- | --- | --- |
| PEO1 | **Preparation** | **P:Preparation** | **Pep-CL abbreviation pronounceasPep-si-lL easy to recall** |
| PEO2 | **CoreCompetence** | **E:Environment**  **(Learning Environment)** |
| PEO3 | **Breadth** | **P: Professionalism** |
| PEO4 | **Professionalism** | **C:CoreCompetence** |
| PEO5 | **Learning**  **Environment** | **L:Breadth(Learningin**  **diverse areas)** |

**ProgramOutcomes(PO):**(statementsthatdescribe whata studentshouldbe able todoandknowby the end of a program)

## Keywordsof 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

**PSOKeywords:** Cuttingedge technologies, Research

“Iaman engineer, and Iknow 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-edgetechnologies and Research*.

**Integrity:**Iwilladhere tothe LaboratoryCode ofConductandethicsinitsentirety.

**VAIDEHI BISEN**

## NameandSignature ofStudentand Date

(SignatureandDateinHandwritten)

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Session** | **2025-26(ODD)** | | **CourseName** | **HPCLab** |
| **Semester** | **7** | | **CourseCode** | **22ADS706** |
| **RollNo** | **26** | | **NameofStudent** | **VAIDEHI BISEN** |
|  | | | | |
| PracticalNumber | | **4** | | |
| CourseOutcome | | 1. UnderstandandApplyParallelProgramming Concepts 2. AnalyzeandImproveProgramPerformance. 3. DemonstratePracticalSkillsinHPCToolsand Environments. | | |
| Aim | | **MatrixMultiplicationusingOpenMP** | | |
| Problem Definition | | Tounderstandhowlongaprogramruns. To identify bottlenecks.  Tooptimizecodeandcomparedifferentimplementations.  TobenchmarkHPCapplications. | | |
| Theory  (100 words) | | This practical demonstrates the importance of measuring program performance for analyzing execution efficiency, identifying bottlenecks, and optimizing code. Using a matrix multiplication example,wefirstimplementedaserialversionandmeasuredexecution  time with the C clock() function. Then, we parallelized the computationusingOpenMP,measuringtimewith  omp\_get\_wtime().Resultsshowedsignificantspeedupwhenusing multiple threads, highlighting the effectiveness of shared-memory parallelism in High-Performance Computing (HPC). Performance measurementallowsfaircomparisonbetweenserialandparallel  implementations,ensuringoptimizedresourceutilization.Overall,the | | |

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |
| --- | --- |
|  | experiment emphasizes benchmarking as a critical step in developing efficient and scalable applications. |
| Procedureand Execution  (100 Words) | **Algorithm:**  **Input**:ReadmatrixsizeNNN.  **Initialize**:AllocatememoryformatricesA,B,CA,B,CA,B,C.Fill AAA with 1.0 and BBB with 2.0.  **SerialExecution**:   * Recordstart timeusingclock(). * Performtriple-nestedloopmultiplication C[i][j]=∑A[i][k]×B[k][j]C[i][j] = \sum A[i][k] \times   B[k][j]C[i][j]=∑A[i][k]×B[k][j].   * Recordendtime andcomputeelapsedtime.   **ParallelExecution**:   * UseOpenMP#pragmaompparallelfortodistribute loop iterations among threads. * Recordtimewithomp\_get\_wtime().   **Output**:Printexecutiontimesforbothversions.  **Compare**:Analyzeperformancegainfromparallelization. |

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |
| --- | --- |
|  | Code:  **Step1:Writetheserial(single-threaded)matrix multiplication code**  Saveas matmul\_serial.c:  #include &lt;stdio.h&gt; #include&lt;stdlib.h&gt; #include &lt;time.h&gt;  voidmatmul(intN,double\*A,double\*B,double\*C){ for (int i = 0; i &lt; N; i++)  for(intj=0;j&lt;N;j++){ double sum = 0;  for (int k = 0; k &lt; N; k++) sum+=A[i\*N+k]\*B[k\*N+j]; C[i\*N+j] = sum;  }  }  intmain(intargc,char\*\*argv){ if (argc &lt; 2) {  printf(&quot;Usage:%smatrix\_size\n&quot;,argv[0]); return 1;  }  int N= atoi(argv[1]);  double\*A=malloc(N\*N\*sizeof(double)); double\*B=malloc(N\*N\*sizeof(double)); double \*C = malloc(N\*N\*sizeof(double));  //InitializematricesAandB  for(inti=0;i &lt;N\*N;i++) { |

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |
| --- | --- |
|  | A[i] =1.0;  B[i] =2.0;  }  clock\_tstart=clock(); matmul(N, A, B, C); clock\_t end = clock();  double time\_spent = (double)(end - start) / CLOCKS\_PER\_SEC; printf(&quot;SerialMatMulelapsedtime:%fseconds\n&quot;,time\_spent); free(A); free(B); free(C);  return 0;  }  **Step2:Compileandrun theserialprogram**  gcc -o matmul\_serial matmul\_serial.c  ./matmul\_serial 500Youwillseeoutputlike:  SerialMatMulelapsedtime:12.345678seconds  **Step3:AddOpenMPparallelizationandtiming**  Saveas matmul\_openmp.c:  #include &lt;stdio.h&gt; #include&lt;stdlib.h&gt; #include &lt;omp.h&gt;  voidmatmul(intN,double\*A,double\*B,double\*C){ #pragma omp parallel for collapse(2)  for(int i=0; i &lt; N; i++)  for(intj=0;j &lt;N;j++) { |

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |
| --- | --- |
|  | double sum =0;  for (int k = 0; k &lt; N; k++) sum+=A[i\*N+k]\*B[k\*N+j]; C[i\*N+j] = sum;  }  }  intmain(intargc,char\*\*argv){ if (argc &lt; 2) {  printf(&quot;Usage:%smatrix\_size\n&quot;,argv[0]); return 1;  }  int N= atoi(argv[1]);  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 &lt; N\*N; i++) {  A[i] =1.0;  B[i] =2.0;  }  doublestart=omp\_get\_wtime(); matmul(N, A, B, C);  double end = omp\_get\_wtime();  printf(&quot;OpenMPMatMulelapsedtime:%fseconds\n&quot;,end-start); free(A); free(B); free(C);  return 0;  }  **Step4:Compileand runtheOpenMPversion** |

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |
| --- | --- |
|  | gcc -fopenmp -o matmul\_openmp matmul\_openmp.c  exportOMP\_NUM\_THREADS=4#Setnumberofthreadsto 4  ./matmul\_openmp 500 |
| Output: |

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |
| --- | --- |
|  |  |
| OutputAnalysis | Theserialimplementationofmatrixmultiplicationtookaround  0.377589 seconds, while the OpenMP-parallelized version completed in0.084889secondsusing4threads.Thisshowsaclearperformance |

# DepartmentofComputerTechnology

### VisionoftheDepartment

Tobeawell-knowncentreforpursuingcomputereducationthroughinnovativepedagogy,value-basededucationandindustrycollaboration.

### MissionoftheDepartment

Toestablish learning ambience forusheringincomputer engineering professionalsincore andmultidisciplinary areabydevelopingProblem-solving skills through emerging technologies**.**

|  |  |
| --- | --- |
|  | improvementwithparallelization.Initially,compilationerrorsoccurred becauseofincorrectcharacters(&lt;insteadof<)duetoHTMLentity issueswhencopyingcode,butaftercorrectionstheprogramcompiled  successfully. The results demonstrate that OpenMP significantly reduces execution time by distributing work across multiple threads. ThisconfirmsthebenefitofparallelprogramminginHigh-Performance Computing (HPC) environments, where optimizing execution time is essential for large-scale applications. |
| Linkofstudent Github profile where lab assignmenthas been uploaded | <https://github.com/VaidehiBisen14/HIGH-PERFORMANCE-COMPUTING> |
| Conclusion | The practical demonstrates that parallelization using OpenMP significantly reduces execution time compared to serial execution, provingtheimportanceofperformancemeasurementand optimization in developing efficient high-performance computing applications. |
| Plag Report (Similarityindex  <12%) |  |
| Date | **02/09/25** |