0016

National University of Computer and Emerging Sciences
Lahore Campus

Parallel and Distributed Computing (CS3006)

Sessional-I Exam

Date: February 24th, 2025

Total Time (Hrs.):	**1**
Total Marks:	**60**
Total Questions:	**6**

Course Instructor(s)
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22L-6790 ________ Roll No

6A ________ Section

________ Student Signature

Instructions / notes:

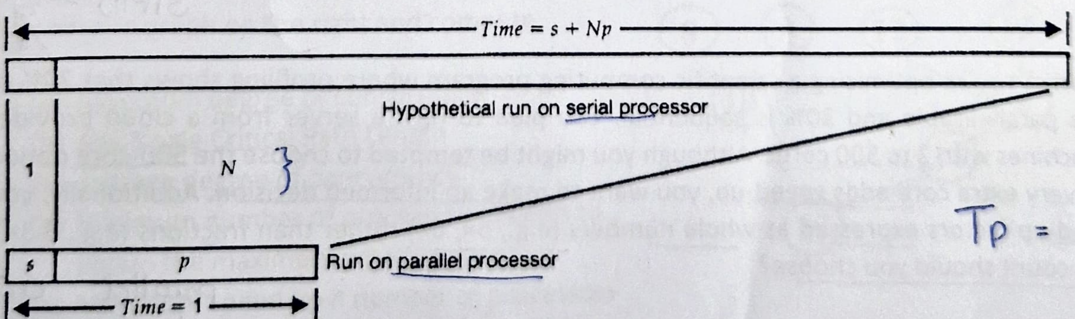
1. Attempt all questions on the answer sheet.
2. If a question is ambiguous, note it, assume clarifying details, and solve it.
3. Include all work with your answer; do not use a separate rough sheet.
4. We estimate that you need no more than 10 minutes on any question. Pace yourself accordingly.

CLO 3: **Perform analytical modelling, dependence, and performance analysis of parallel algorithms and programs.**

Q1a: [2 marks] How does Gustafson's law differ from Amdahl's law?

↳ processor may increase ↳ static processor

Q1b: [4 marks] Derive Gustafson's law using the symbols provided in the diagram below. Clearly mention what each symbol means. Your final expression should be in terms of *N* and *s* only.



$T_p = T_s + T_p$

Q1c: [2 marks] What are the two assumptions made in the above derivation?

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CLO 3: Perform analytical modelling, dependence, and performance analysis of parallel algorithms and programs.

Q2a: [2 marks] Write Amdahl's law and Karp-Flat metric (K-F metric) formula (no derivation needed).

$1/f + \frac{1-f}{p}$ $\quad e = 1/s + 1/p \,/\, 1 - 1/p$

Q2b: [4 marks] Assume that 90% of an algorithm can be parallelized while the remaining 10% must be executed sequentially. We have partially filled the following table for you with 4 missing values (A to D). Calculate these four missing values using formulae you mentioned above.

Number of Processors used	2	4	6	8
Amdahl's speedup	A	3.077	4	4.706
← Gustafson's speedup	B	3.7	5.5	7.3
$S + N(1-S)$ K-F metric using Amdahl's speedup	C	0.1	0.1	0.1
K-F metric using Gustafson's speedup	D	0.027	0.018	0.014

Q2c: [2 marks] Review the K-F metric derived from Amdahl's speedup in your completed table. What conclusions can you draw, and why?

Q2d: [2 marks] Review the K-F metric derived from Gustafson's speedup in your completed table. What conclusions can you draw, and why?

Q2e: [2 marks] Previously, we computed K-F metric values using theoretical speed-up figures from Amdahl's or Gustafson's law rather than measuring them directly by executing the code. For a fixed workload, would you expect such experimental K-F values to decrease, increase, or remain constant—and why?

CLO 3: Perform analytical modelling, dependence, and performance analysis of parallel algorithms and programs.

Q3a: [4 marks] You are designing a cloud-based image processing service where each uploaded image is independently transformed (e.g., resized and enhanced). With thousands of concurrent uploads, which Flynn's Taxonomy architecture best supports parallelism and scalability? (Just name it.) Provide rationale for your answer in a line.

↓
SIMD → same set of instru to display.

Q3b: [8 marks] You're optimizing a scientific computing program where profiling shows that 70% of the work is parallelizable and 30% is sequential. You plan to rent a server from a cloud provider offering machines with 2 to 500 cores. Although you might be tempted to choose the 500-core option assuming every extra core adds speed-up, you want to make an informed decision. Additionally, you prefer speed-up factors expressed as whole numbers (e.g., 5×, 6×) rather than fractions (e.g., 5.3×). Which core count should you choose?

parallel 0.7
serial 0.3

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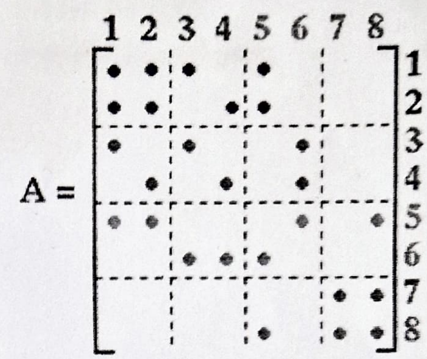
CLO 3: **Perform analytical modelling, dependence, and performance analysis of parallel algorithms and programs.**

Q4: [8 marks] Consider the problem of computing the product **y** = **Ab**, where A is a sparse 8 x 8 matrix and b is a dense 8 x 1 vector.

A matrix is considered *sparse* when a significant number of its entries are zero, and the locations of the non-zero entries do not conform to a predefined structure or pattern.

The matrix A is shown on the right, with the non-zero elements represented by dots. Create a task interaction graph for this problem, such that i^{th} task computes the entry of y[i] and owns the i^{th} row of A and the element b[i].



CLO 1: **Demonstrate understanding of various concepts involved in parallel and distributed computer architectures.**

Q5a: [2 marks] Draw a 4x4 Omega network for processors P0–P3 and memory modules M0–M3.

Q5b: [2 marks] Explain how P3 will access M2 in terms of routing?

Q5c: [2 marks] How many switching stages will be required for this network?

Q5d: [2 marks] Can P1 to M2 and P3 to M3 communications happen in parallel? Why or why not?

Q5e: [2 marks] How many switching nodes will be required for this network?

CLO 3: **Perform analytical modelling, dependence, and performance analysis of parallel algorithms and programs.**

Q6: [2+2+2+2+2 marks] Examine the task-dependence graph on the right and compute:

(a) Maximum degree of concurrency
(b) Any Single Critical Path Length
(c) Average degree of concurrency
(d) Minimum number of processors needed to obtain the maximum possible speedup
(e) Maximum speed up if number of processors are limited to 4