



# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 8, Examination in Engineering, September 2023

**Module Number: EE8207    Module Name: High Performance Computing**

[Three hours]

[Answer all questions]

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- Q1. a) Briefly explain the major difference between a multi-threaded program and a distributed memory program. [2 Marks]
- b) State three (3) technologies that can be used for multi-threaded programming. Note that for each programming language there are unique threading technologies. [2 Marks]
- c) Write a program to demonstrate how point-to-point communication can be achieved with MPI, wherein process 0 sends an integer with the value of 5 to process 2. Exact API endpoints are not necessary; you may use pseudo-code to craft the program. [4 Marks]
- d) State three (3) collective communication techniques and provide pseudo-code to demonstrate how each can be used. [2 Marks]
- Q2. a) Assume you are given a task to write a program using collective communication techniques to calculate the mean value of a column in a dataframe/table containing numerical values.
- i) What is the collective communication operator you are planning to use for the above task? [1 Mark]
- ii) Are there any other operators which can do the same task? [0.5 Marks]
- iii) Is the method you chose the most efficient? Justify your answer. [0.5 Marks]
- iv) Write a pseudo-code to illustrate how a program can be written to solve this problem. [3 Marks]

- b) Various techniques can be used to partition data in persistent storage (disk) using an MPI program. Answer the following questions.
- i) State three (3) data partition algorithms. Use the most suitable algorithm from the stated and use an example or examples to support your answer. [2 Marks]
  - ii) Describe two (2) scenarios associated with multiple file handling and load balancing during data partitioning. [3 Marks]
- Q3. a) You are given a task to write a simple OpenMP program to demonstrate how multi-threading can be introduced to a program.
- i) Briefly explain your program. [1 Mark]
  - ii) What is a commonly faced issue with multi-threaded programs? [1 Mark]
  - iii) Write your program using pseudo-code. [3 Marks]
- b) Imagine you have a program written in MPI. And you want to parallelize the program further using OpenMP. Based on this scenario, answer the following questions.
- i) Briefly explain your sample application. [1 Mark]
  - ii) How is MPI used in your program? [0.5 Marks]
  - iii) How is OpenMP used in your program? [0.5 Marks]
  - iv) Write your program using pseudo-code? [3 Marks]
- Q4. a) You are given a task to write a simple CUDA program to demonstrate how an integer can be multiplied by 2 using a GPU device.
- i) How will you use a GPU to process your data? What are the main steps associated with handling memory? Note that the steps are finite and well defined. [1 Mark]
  - ii) Write a pseudo-code to show how you would do the computation? [1 Mark]
- b) Describe the difference between an MPI program and a CUDA program. [1 Mark]

c) State two (2) scenarios where GPU computing is more advantageous compared to CPU computing. Please explain using existing knowledge of various computational problems to support your statement.

[2 Marks]

d) Explain how to assess the performance of three (3) types of programs aimed at solving a particular problem: a sequential program, an MPI program, and a hybrid program combining MPI and OpenMP. Assume that these programs need to load data in parallel, perform computations, engage in collective communication, and then save the results to disk. It's important to note that while each program tackles the same issue, they differ only in their parallelism approach.

[3 Marks]

e) State two (2) advantages and two disadvantages of hybrid programs written using MPI and OpenMP. Use examples to support your statement.

[2 Marks]

Q5. a) State three (3) data partitioning techniques that can be used in various applications.

[2 Marks]

b) Describe how a distributed join can be designed using MPI parallelization techniques. Enumerate all the steps of the program. The use of pseudo-code is optional for this problem.

[4 Marks]

c) Describe how a machine learning algorithm can be parallelized using MPI. State the stages of the program and explain the actions performed in each stage.

[4 Marks]