King Fahd University of Petroleum & Minerals
College of Computing and Mathematics
Department of Mathematics

MATH 578 Applied Numerical Methods II, Term 261

Instructor: Dr. Abdullah Shah

Course Description:

This course introduces finite elements, finite differences, and finite volume methods. The methods are applied to steady-state, diffusion, and wave models. Stability and convergence. Homogenization, upscale, and multiscale methods. Implementations and computer labs.

Course Objective:
The objectives of the course are to:

1. Provide students with a strong foundation in Numerical Methods for PDEs.
2. Use computing software for hands-on knowledge and practical implementation.

Learning Outcomes: By the end of this course, students will be able to:
1. Describe finite difference, Galerkin finite element, and finite volume methods.
2. Apply finite difference, finite element and finite volume methods for solving steady-state and time-dependent models.
3. Evaluate the accuracy and stability of the numerical solutions.
4. Construct finite element solutions in multiscale domains.

Credit hours: 3

Primary Textbook

1. Grossmann, C., Roos, H.-G., & Stynes, M. (2007). *Numerical Treatment of Partial Differential Equations*. Springer.

Supplementary References

2. Larsson, S., & Thomée, V. (2003). *Partial Differential Equations with Numerical Methods*. Springer.
3. Efendiev, Y., & Hou, T. Y. (2009). *Multiscale Finite Element Methods: Theory and Applications*. Springer.
4. Knabner, P., & Angermann, L. (2003). *Numerical Methods for Elliptic and Parabolic Partial Differential Equations*. Springer.

Honor code:

Students of this course are expected to maintain the highest level of academic integrity and ethics. A KFUPM student does not cheat or tolerate those who do. Every student is expected to submit work that is entirely their own, to properly cite all sources used, and to refrain from any form of *academic misconduct*.

Plagiarism:

Use of another person's ideas, processes, results, or words requires appropriate credit or reference to the author. Use of Generative AI tools is subject to the instructor's authorization. Submitting the same work on more than one course without the instructor's permission is not allowed.

Class Attendance:
Students are expected to arrive on time for class, consistent with expectations in professional settings. Recording attendance for another student, signing another student's attendance, or asking another student to record yours will be reported for investigation and may result in severe consequences for both students involved.

Examination Policies
Students are expected to adhere to KFUPM policies for all examinations in this course, including quizzes, major exams, midterms, and final exams. The following policies are enacted in this course during examinations:

- Students are expected to arrive at the examination hall on time with proper University ID.
- Students are seated according to the instructor's seat assignment and may request a seat change only for legitimate reasons.
- Late arrival at the exam may result in the student being denied admission. Once any student has begun finishing the exam, no further admission will be allowed under any circumstance.
- Students are not permitted to leave the examination room to use the restroom during an exam, except in rare cases involving a documented medical condition (e.g., diabetes, kidney disease). Any excused restroom leave will be fully supervised by a same-gender proctor.
- Students must leave all smart devices outside the examination hall, including smartphones, smartwatches, earbuds, and unauthorized calculators. Possession of any unauthorized device will be considered a cheating attempt and will be handled accordingly.
- Cheating attempts will be reported according to KFUPM policy and will result in a DN grade in the course, along with potential further penalties upon investigation.

Office Hours: Sunday and Tuesday, 3:00–4:00 PM, or by appointment via email or MS Teams.

Email: abdullah.shah.1@kfupm.edu.sa **Office location:** Building 5, Room 419

Course Grade Distribution
The final grade will be based on the following distribution:

Exam I		20%
Exam II		20%
Assignments		15%
Project		10%
Final Exam		35%
Total		**100%**

Topics

1 Introduction and Motivations

Elliptic and Mixed Type Problems in 1D and 2D

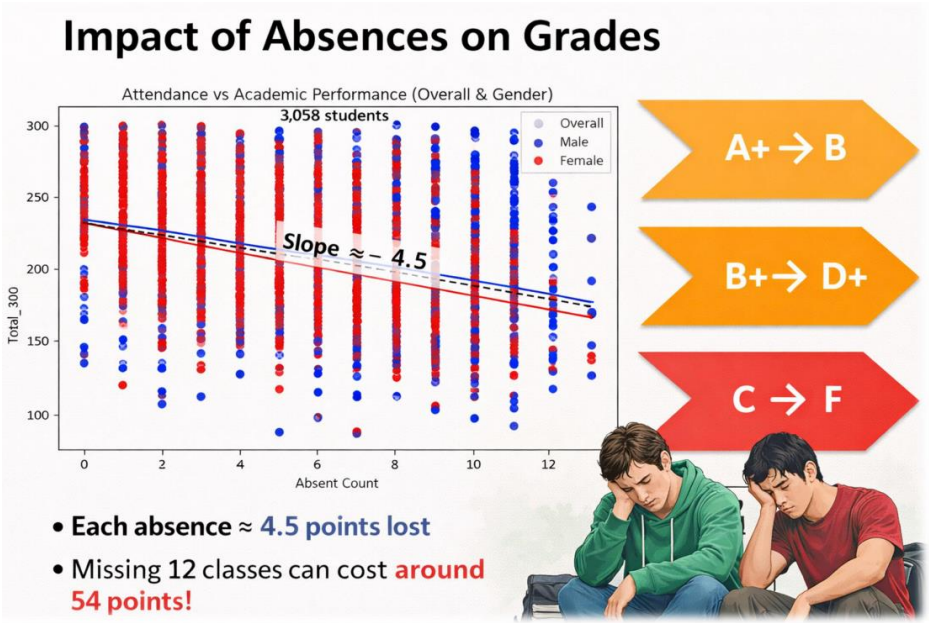
2 Finite Difference Method
Matrix Structure
Numerical Stability and Convergence
Implementation

3 Finite Element Method
Quadrature and Mesh Generation
Stability and Convergence
Implementation/ Matlab PDE Toolbox

Time Dependent Models

4 Time-Stepping Finite Differences
Semi-Discrete Finite Elements
Implementations

5 Finite Volume Method for Hyperbolic Problems.



Office Hours:

Course	SUNDAY	TUESDAY	THURSDAY
MATH578	15:00-15:50	15:00-15:50	-

Remark: Students can also ask for an appointment by email or MS TEAMS.

Good Luck