

**King Fahd University of Petroleum & Minerals**

**Department of Mathematics**

**Math 208 Syllabus, Semester 261 (2026-2027)**

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**Course Code & Title:** Math 208, Differential Equations and Linear Algebra.

**Course Credit Hours:** 3-0-3.

**Textbook:** Edwards, C. H., Penney, D. E., and Calvis, D. T., Differential Equations and Linear Algebra, **Fourth edition**, Pearson, 2021.

**Course Description:** Systems of linear equations. Vector spaces  $\mathbb{R}^n$ : subspaces, bases, dimensions. Rank of matrices. Eigenvalues and eigenvectors. Similar matrices. Diagonalizable matrices. Matrix exponential. First-order differential equations: separable, linear, exact, substitution methods. Applications to linear models of first order. The homogeneous differential equations with constant coefficients. Wronskian. Nonhomogeneous differential equations. Methods of undetermined coefficients and variation of parameters. Systems of differential equations. Non-homogeneous systems. Series solutions.

**Prerequisite:** Math 102.

**Course Objectives:**

1. To introduce students to the basics of linear algebra in  $\mathbb{R}^n$ .
2. To introduce students to the basic types of differential equations and various techniques used to solve them.

**Course Learning Outcomes:** Upon the completion of the course, students should be able to

1. Demonstrate understanding of basic concepts of differential equations and linear algebra.
2. Solve various types of first-order ordinary differential equations.
3. Apply differential equations to model and solve selected real-world problems.
4. Solve problems involving matrices, linear systems, eigenvalues and eigenvectors, matrix exponentials, and the vector space  $\mathbb{R}^n$ .
5. Solve homogeneous and nonhomogeneous ODEs with constant coefficients.
6. Solve linear systems of differential equations with constant coefficients.
7. Use power series to solve second-order differential equations.

| Grading Policy   | Date                                                                                                                                                                                                                                                                                                                                                                    | Time | Place | Material      | Points | %   |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|---------------|--------|-----|
| Exam I (15 MCQ)  | Monday, Sep. 28, 2026                                                                                                                                                                                                                                                                                                                                                   | TBA  | TBA   | 1.1 - 4.2     | 75     | 25  |
| Exam II (15 MCQ) | Monday, Nov. 2, 2026                                                                                                                                                                                                                                                                                                                                                    | TBA  | TBA   | 4.3 - 6.2     | 75     | 25  |
| Final (21 MCQ)   | TBA                                                                                                                                                                                                                                                                                                                                                                     | TBA  | TBA   | Comprehensive | 105    | 35  |
| Class Work       | <div><div><div>▪ It is based on quizzes, class tests, or other class activities determined by the instructor.</div><div>▪ The average (out of 45) of the class work of each section has to be in the interval <math>[y - 1.5, y + 1.5]</math>, where <math>y = \frac{9}{40}(\text{median}(\text{Exam I})\% + \text{median}(\text{Exam II})\%)</math>.</div></div></div> |      |       |               | 45     | 15  |
| Total            |                                                                                                                                                                                                                                                                                                                                                                         |      |       |               | 300    | 100 |

**Letter Grades:** Final letter grades will be assigned according to a grading curve, which will be determined based on the overall performance of all students enrolled in the course. The exact cutoffs may change from one term to another, depending on how the scores are distributed.

**Exam Questions:** Exam questions will be similar in style and level of difficulty to the examples and exercises provided in the textbook.

**Examination Policies:** You 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 to the exam may result in the student being denied admission. Once a student has completed the examination and left the examination hall/room, no late student will be admitted.
- 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.

**Missing an Exam:** In case a student misses an exam (Exam I, Exam II, or the Final Exam) for a legitimate reason (such as medical emergencies), the student must submit an official excuse approved by the Deanship of Student Affairs within **seven calendar days** of the missed exam date. Without an approved excuse, the student will receive a score of zero for the missed exam. When the excuse is accepted, the coordinator will arrange a makeup exam for the missed exam.

**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.

A DN grade will be given after two warnings if a student

- exceeds 9 unexcused absences (20% of the course)
- or exceeds a total of 15 absences whether excused or not (one-third of the course).

**Use of Mobile Devices in Class:** The use of mobile phones during class is strictly prohibited. Students who wish to use laptops or tablets for notetaking must first obtain permission from the instructor. Any violation will result in a penalty determined by the instructor.

**Academic Integrity:** All KFUPM academic integrity policies apply to this course. For details, students should refer to the Undergraduate Bulletin available on the Registrar's website.

**Accessibility and Accommodations:** Students with documented special needs, approved by the Deanship of Student Affairs, should contact the course coordinator to arrange reasonable accommodation.

**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 in more than one course without the instructor's permission is not allowed.

### Suggested Weekly Coverage Plan

| Week                             | Date (2026)       | Sec.                                              | Topics (25 sections)                                                                             |
|----------------------------------|-------------------|---------------------------------------------------|--------------------------------------------------------------------------------------------------|
| 1                                | Aug. 19 - 20      | 1.1                                               | Differential Eq. & Math. Models<br>(Math Models: Examples 3, 5, 6 only)                          |
| 2                                | Aug. 23 - 27      | 1.2                                               | Integrals as General and Particular Solutions                                                    |
|                                  |                   | 1.4                                               | Separable Equations & Applications ( <b>Natural Growth &amp; Decay + Cooling &amp; Heating</b> ) |
| 3                                | Aug. 30 - Sept. 3 | 1.5                                               | Linear First-Order Equations                                                                     |
|                                  |                   | 1.6                                               | Substitution Methods & Exact Equations                                                           |
| 4                                | Sept. 6 - 10      | 1.6                                               | Substitution Methods & Exact Equations (Continue)                                                |
|                                  |                   | Ch 3                                              | <b>Review only:</b> Solving Linear Systems by Gaussian Elimination, Inverse, Determinant         |
| 5                                | Sept. 13 - 17     | 4.1                                               | The Vector Space $\mathbb{R}^3$                                                                  |
|                                  |                   | 4.2                                               | The Vector Space $\mathbb{R}^n$ and Subspaces                                                    |
| 6                                | Sept. 20 - 22     | 4.3                                               | Linear Combinations & Independence of Vectors                                                    |
|                                  |                   | 4.4                                               | Bases & Dimension for Vector Spaces                                                              |
|                                  | Sept. 23 - 24     | Wednesday - Thursday: <b>National Day Holiday</b> |                                                                                                  |
| 7                                | Sept. 27 - Oct. 1 | EXAM I                                            | <b>Monday, Sept. 28, 2026; Material: 1.1 - 4.2.</b>                                              |
|                                  |                   | 4.5                                               | Row and Column Spaces ( <b>Definition of the Rank of a Matrix only</b> )                         |
|                                  |                   | 5.1                                               | Introduction: 2 <sup>nd</sup> -Order Linear Eq.                                                  |
| 8                                | Oct. 4 - 8        | 5.2                                               | General Solutions of Linear Eq.                                                                  |
|                                  |                   | 5.3                                               | Homogeneous Eq. with Constant Coefficients                                                       |
| 9                                | Oct. 11 - 15      | 5.5                                               | Nonhomogeneous Eq.: Undetermined Coeff. & Method of Variation of Parameters                      |
| 10                               | Oct. 18 - 19      | 6.1                                               | Introduction to Eigenvalues                                                                      |
|                                  | Oct. 20 - 22      | Tuesday - Thursday: <b>Midterm Break</b>          |                                                                                                  |
| 11                               | Oct. 25 - 29      | 6.1                                               | Introduction to Eigenvalues (Continued)                                                          |
|                                  |                   | 6.2                                               | Diagonalization of Matrices                                                                      |
| 12                               | Nov. 1 - 5        | EXAM II                                           | <b>Monday, Nov. 2, 2026; Material: 4.3 - 6.2.</b>                                                |
|                                  |                   | 7.2                                               | Matrices & Linear Systems                                                                        |
|                                  |                   | 7.3                                               | The Eigenvalue Method for Linear Systems                                                         |
| 13                               | Nov. 8 - 12       | 7.6                                               | Multiple Eigenvalue Solutions ( <b>systems of 2x2 and 3x3 only</b> ) Up to p.462.                |
| 14                               | Nov. 15 - 19      | 8.1                                               | Matrix Exponentials & Linear Systems (up to p. 490)                                              |
| 15                               | Nov. 22 - 23      | Sunday - Monday: <b>Autumn Break</b>              |                                                                                                  |
|                                  | Nov. 24 - 26      | 8.2                                               | Nonhomogeneous Linear Systems (only Variation of Parameters Method)                              |
| 16                               | Nov. 29 - Dec. 3  | 11.1                                              | Introduction and Review of Power Series                                                          |
|                                  |                   | 11.2                                              | Power Series Solutions (Ordinary Points)                                                         |
| 17                               | Dec. 6 - 10       | 11.3                                              | Frobenius Series Solutions (Singular Points)                                                     |
| <b>Final Exam: Comprehensive</b> |                   |                                                   |                                                                                                  |

## Suggested Practice Problems

| Sec  | Problems Numbers                                                                                                                              |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1.1  | 6, 8, 10, 14, 20, 25, 35, 38, 39                                                                                                              |
| 1.2  | 2, 6, 7, 10, 11, 17                                                                                                                           |
| 1.4  | 2, 8, 10, 24, 26, 29 (a, b), 33, 34, 40, 43, 49                                                                                               |
| 1.5  | 3, 10, 18, 21, 24, 28, 30                                                                                                                     |
| 1.6  | 16, 17// 2, 8, 13// 19, 24, 27// 32, 36, 40// 44, 46, 52                                                                                      |
|      |                                                                                                                                               |
| Ch 3 | 3.1: 4, 13, 18, 19, 24<br>3.2: 2, 10, 15, 28<br>3.3: 2, 6, 10, 26, 28<br>3.4: 1, 10, 14, 23<br>3.5: 3, 13, 23<br>3.6: 2, 3, 7, 17, 21, 27, 33 |
|      |                                                                                                                                               |
| 4.1  | 1, 4, 6, 8, 10, 16, 19, 20, 25, 32, 34                                                                                                        |
| 4.2  | 2, 8, 12, 14, 17, 19                                                                                                                          |
| 4.3  | 2, 6, 12, 17, 23                                                                                                                              |
| 4.4  | 2, 8, 9, 12, 13, 16, 23                                                                                                                       |
| 4.5  | Find the rank of the matrix: 1, 4, 8, 12                                                                                                      |
|      |                                                                                                                                               |
| 5.1  | 10, 15, 19, 20, 26, 29, 38, 39, 43                                                                                                            |
| 5.2  | 3, 9, 14, 22, 26, 30                                                                                                                          |
| 5.3  | 3, 4, 14, 19, 22, 28, 31, 33, 39, 40                                                                                                          |
| 5.5  | 1, 4, 8, 16, 27, 29, 39, 41// 48, 52, 57, 60, 62                                                                                              |
|      |                                                                                                                                               |
| 6.1  | 3, 7, 14, 21, 25, 31                                                                                                                          |
| 6.2  | 2, 10, 15, 18, 27                                                                                                                             |
|      |                                                                                                                                               |
| 7.2  | 1, 6, 9, 12, 16, 20, 24                                                                                                                       |
| 7.3  | 1, 3, 9, 18, 25, 26                                                                                                                           |
| 7.6  | 4, 5, 9, 13, 16                                                                                                                               |
|      |                                                                                                                                               |
| 8.1  | 2, 6, 7, 10, 17, 21, 24, 26, 27                                                                                                               |
| 8.2  | 17, 19, 21, 32                                                                                                                                |
|      |                                                                                                                                               |
| 11.2 | 1, 4, 6, 7, 12, 15, 17, 18                                                                                                                    |
| 11.3 | 4, 6, 8, 9, 12, 18, 21, 25, 27, 32                                                                                                            |

## Guidelines for Effective Study and Problem Solving

Students are encouraged to develop regular, independent, and honest study habits. The following practices can help:

1. For every important concept, method, or skill in a section, solve at least one or two simple examples **by yourself and without help**. If you need help with one example, make sure to solve another similar example on your own afterward.
2. Make sure you can write **a complete solution with clear and logical steps**. If you are unsure about a step or cannot explain why it is correct, this may be a sign that you need more review and practice.
3. Try several problems on your own. If you need help, first identify exactly what caused the difficulty. Review that point, then return to the problem and solve it again from the beginning, **with full details and without help**.
4. Always try to solve a problem before reading the solution, looking at a worked example, or asking for help. Reading the solution too early may make you feel that you understand the problem even when you are not yet able to solve it by yourself.
5. If you find a certain type of problem difficult, practice more problems of the same type until you can solve them correctly and confidently on your own.
6. Practice more problems than those listed or assigned. **Focus on understanding the ideas and methods, not memorizing solutions.**
7. Review the previous lecture before each class.
8. Visit your instructor during office hours whenever you need help. When possible, bring your own attempt or partial solution to the problem you want to discuss. This helps your instructor see where the difficulty is and makes the discussion more useful.

Most importantly, be honest with yourself about your understanding. **Being able to follow a solution is not the same as being able to solve the problem by yourself.** You should aim to reach the point where you can choose the correct method, complete the steps, explain your reasoning, and solve the problem independently.

**Prerequisite Skills:** Students are strongly advised to review and maintain the mathematical skills acquired in MATH 102, particularly techniques of integration, including substitution, integration by parts, trigonometric substitution, and partial fractions.

Students are also encouraged to review basic skills related to matrices, Gaussian elimination, and polynomial factorization.