

MTSE 3040

KINETICS AND TRANSPORT PHENOMENA IN MATERIALS

Course Syllabus • Fall 2026

Instructor: Prof. Srinivasan G. Srivilliputhur
Office: NTDP C136C, srinivasan.srivilliputhur@unt.edu
In-person Lectures: Monday / Wednesday, 10:40 AM – 12:00 PM, DP B157
Office Hours: Mondays at 4:00 PM (via Zoom) or by appointment
Credits: 3 Credit Hours
TA: Mr. Babajide Aremu (BabajideAremu@my.unt.edu)

Textbooks

- **Kinetics in Materials Science & Engineering** — Dennis W. Readey, CRC Press (2017)
- **Materials Kinetics** — John Mauro, Elsevier (2021)

Course Content Overview

The course is organized into six instructional unit modules, from foundational math/kinetic theory through chemical kinetics and diffusion to heat and momentum transport. Lecture notes will be posted on **CANVAS**. **Explainer Videos were made by Gemini AI using Prof. Srivilliputhur's lecture slides as the source material.**

Unit	Topic	Dates
Unit 00	Math Review	Aug 17 – Aug 24
Unit 01	Thermo/Kinetics Review & Molecules in Motion	Aug 26 – Sep 9
Unit 02	Chemical Kinetics	Sep 14 – Sep 30
Unit 03A	Introduction to Diffusion & Fick's Laws	Oct 19 – Oct 28
Unit 03B	Atomistic Mechanisms & Multicomponent Diffusion	Nov 2 – Nov 18
Unit 04	Heat & Momentum Transport	Nov 30 – Dec 2

Detailed Course Topics

UNIT 00 — Math Review

- Calculus: Gradients and integrals
- Ordinary and partial differential equations used in transport problems
- Probability and statistical distributions

UNIT 01 — Thermo/Kinetics Review & Molecules in Motion

- Brief review of thermodynamic potentials and equilibrium concepts
- Maxwell–Boltzmann distribution
- Collision frequency
- Transport processes and their coefficients:
 - Diffusion — mass diffusivity
 - Heat flow — thermal conductivity

UNIT 02 — Chemical Kinetics

- Homogeneous & heterogeneous reactions
- First- and second-order rate equations
- Multi-step reactions
- Calculating rate constants: collision theory & the Arrhenius equation
- Applications of materials kinetics

UNIT 03A — Introduction to Diffusion & Fick's Laws

- Fick's First and Second Laws
- Conservation of mass; the divergence theorem
- Steady-state and transient solutions
- Experimental determination of the mass diffusivity, D

UNIT 03B — Atomistic Mechanisms & Multicomponent Diffusion***Atomic Mechanisms***

- Defects and diffusion
- Random walk and its relation to D — the Einstein–Smoluchowski equation
- Low temperature short-circuit diffusion: dislocation pipes and grain boundaries
- Arrhenius plots — $\ln(D)$ vs. $1/T$ — extended to low temperatures
- Point defects in ionic solids: Kröger–Vink notation & defect reactions
- Ionic conduction and its relation to diffusion (Einstein equation); effect of doping on ion transport

Multi-Component Diffusion

- Kirkendall effect and moving interfaces
- Darken's equations
- Boltzmann–Matano solution

Applications

- Diffusion in crystals and nanocrystalline materials
 - Motion of dislocations, surfaces, and interfaces
- Kinetics of phase separation

UNIT 04 — Heat & Momentum Transport

- Heat conduction: analogy with mass diffusion
- Convection
- Viscosity of liquids
- Introduction to the Navier–Stokes equations (momentum transport)

Specific Course Information

- **Prerequisites:** MATH 1720 (Calculus II), MATH 2700 (Linear Algebra & Vector Geometry), MATH 3410 (Differential Equations I), MTSE 3000. Any other required math will be reviewed in class.
- **Course status:** Required
- **Submissions:** Upload all assignments and quizzes on CANVAS. Emailed answers are not acceptable.

Specific Goals for the Course

Course Learning Outcomes

#	Specific Course Learning Outcome
1	Understand how molecular motion triggers rate processes in materials.
2	Learn the rate processes of chemical kinetics and solve illustrative problems.
3	Solve mass-transport problems in materials processing using Fick's laws of diffusion and mass-balance equations.
4	Learn key materials-processing technologies and apply theory to these technologies.

This course addresses **ABET Student Outcome 7**.

Course Schedule

All dates follow the UNT Fall 2026 academic calendar. Classes meet Monday and Wednesday, 10:40 AM–12:00 PM, in DP B157. No class on Labor Day (Mon, Sep 7) or during Thanksgiving Break (Mon, Nov 23 – Sun, Nov 29).

Unit / Milestone	Class Dates	Assessment
Unit 00 — Math Review	Mon Aug 17 – Mon Aug 24	Quiz 1 (online)
Unit 01 — Thermo/Kinetics Review & Molecules in Motion	Wed Aug 26 – Wed Sep 9	Quiz 2 (online)
Unit 02 — Chemical Kinetics	Mon Sep 14 – Wed Sep 30	Quiz 3 (online)
Unit 03A — Introduction to Diffusion & Fick's Laws	Mon Oct 19 – Wed Oct 28	Quiz 4 (online)
Unit 03B — Atomistic Mechanisms & Multicomponent Diffusion	Mon Nov 2 – Wed Nov 18	Quiz 5 (online)
Unit 04 — Heat & Momentum Transport	Mon Nov 30 – Wed Dec 2	Quiz 6 (online)

Exams & Quizzes

The two exams are in-class and **non-cumulative**. Exam-01 will be given after due announcement, while exam-02 schedule is set by the UNT Registrar. There will be a review session prior to each exam. There will be six online quizzes (one per unit module for 20-30 minutes, administered after that unit is completed). They may include multiple-choice, short-answer, and quantitative problems. **I will consider five best quizzes out of the six for grades.**

Assessment	Format	Timing	Coverage
Quiz 1	Online (CANVAS)	After Unit 00 is completed	Unit 00: Math Review
Quiz 2	Online (CANVAS)	After Unit 01 is completed	Unit 01: Thermo/Kinetics Review & Molecules in Motion
Quiz 3	Online (CANVAS)	After Unit 02 is completed	Unit 02: Chemical Kinetics
Exam 1	DP B157, 80 min	TBD, Oct	Units 00, 01 & 02 (not cumulative)
Quiz 4	Online (CANVAS)	After Unit 03A is completed	Unit 03A: Introduction to Diffusion & Fick's Laws
Quiz 5	Online (CANVAS)	After Unit 03B is completed	Unit 03B: Atomistic Mechanisms & Multicomponent Diffusion
Quiz 6	Online (CANVAS)	After Unit 04 is completed	Unit 04: Heat & Momentum Transport
Exam 2	DP B157, 120 min	Sat, Dec 05, 10:30 AM–12:30 PM	Units 03A, 03B & 04 (not cumulative)

- Each exam covers only the units listed above.
- I will return graded exams within two weeks. This may take longer in case of other faculty commitments.
- Only a non-programmable calculator, pencils, pens, and an eraser are permitted during quizzes and exams.
- Earphones, cell phones, laptops, smart watches, and other electronic devices are banned during exams.

Grading Rubric

Activity	Weight	Details
Homework	20%	Five assignments, equally weighted
Quizzes	20%	Six online quizzes, equally weighted
Exam 1	30%	In-class, covers Units 0, 1 & 2A
Exam 2	30%	In-class, covers Units 2B, 3 & 4

Final Letter Grades (curved)

A ≥ 90% **B** ≥ 80% and < 90% **C** ≥ 70% and < 80% **D** ≥ 60% and < 70% **F** < 60%

Important Class Policies

CANVAS

CANVAS is used primarily for posting announcements, lecture slides, assignments, and solutions.

Lectures

Lectures cover the theory of and problems in rate phenomena. Often, a problem illustrating the theory will be presented during a lecture, and students are encouraged to solve it during class. A discussion and solution will be presented during office hours on Mondays.

Homework

About six assignments will be given, involving graphing and solving differential equations (a prerequisite for this class). Relevant statistical concepts will be introduced as needed.

Homework problems will challenge you. **Please don't wait until the last minute to solve them.** Guidance is available during office hours — but you must attempt each problem first.

Homework due dates are posted on CANVAS. Late homework receives partial credit only until solutions are posted; no late homework is accepted after solutions are posted.

Many students prefer Excel, but it is tedious for scientific computation and plotting. A computational tool such as Python, R, MATLAB, or Mathematica will help considerably with assignments — use of software is entirely optional. From this year onward, the course uses Python with Jupyter notebooks for assignments; syntax questions are welcome.

Office Hours

Office hours are used for homework help, clarifying doubts, and conceptual questions. Historically, students who ask questions during office hours and/or listen to others' questions tend to do better in the class.

Problem Sets

Based on student feedback, more example problem sets will be solved in class. About five problem sets covering each unit of lectures will be given; work through these with your peers first, and they will be discussed in class.

Class Attendance

Class attendance is mandatory. Optimal learning demands regular attendance and active participation in classroom discussion. Notify the instructor in advance if you must miss a class or will be late. Being more than 15 minutes late on a regular basis is disruptive and unacceptable. Ten or more unexcused absences will lead to a student being dropped from the class.

Calculators

A non-programmable calculator may be used but may not be shared with peers during exams. Your calculator must be able to compute trigonometric ($\sin$, $\cos$, $\tan$), exponential (e^x), power (x^y), square root, natural log ($\ln$), base-10 log ($\log$), and inverse functions.

Cell Phone Usage

Cell phones and other electronic communication devices must remain out of sight during class time. Texting, browsing, messaging, and gaming during class are prohibited; students violating this policy will be asked to leave class.

Makeup Exam Policy

Makeup exams are allowed only for mitigating circumstances such as business travel or serious illness of the student or a close family member. Students facing such situations must notify the instructor by email and provide documentation (e.g., a doctor's note).

University Policies

Disability Accommodation

UNT complies with Section 504 of the 1973 Rehabilitation Act and the Americans with Disabilities Act of 1990, providing reasonable accommodation and auxiliary aids to individuals with disabilities as defined under the law. If you believe you have a disability requiring accommodation, contact the Office of Disability Access at 940-565-4323 during the first week of class. See the ODA website: <https://disability.unt.edu/>.

Authorized Absences & Extenuating Circumstances

Excused absences include illness, conference travel, participation in university-sponsored activities, family emergency, religious holidays, and other unplanned difficulties as determined by the instructor. Absences must be verified (e.g., by the Dean of Students or a doctor's note); consideration is given only for quizzes and exams. Participation in sponsored activities requires prior approval. For extenuating circumstances, contact the instructor within one week.

Absence for Religious Holidays

State law allows a student absent due to observance of a religious holiday to take exams or complete assignments scheduled for the missed day(s) within a reasonable time after the absence. Only holidays observed by a religion whose place of worship is tax-exempt under Section 11.20 of the Texas Tax Code are eligible. Notify the instructor of anticipated absence dates before the end of the second week of the semester.

Academic Integrity

Per UNT Policy 06.003 (Student Academic Integrity), academic dishonesty includes, but is not limited to, cheating, fabrication, facilitating academic dishonesty, forgery, plagiarism, and sabotage. Students must conduct themselves professionally and act honestly and ethically in all academic work.

- **Assisting** — helping another commit an act of academic dishonesty
- **Cheating** — use or attempted use of unauthorized materials, information, or study aids
- **Fabrication** — falsification or invention of information
- **Plagiarism** — representing another person's words or ideas as one's own
- **Tampering** — altering or interfering with evaluation instruments or documents

Academic dishonesty such as plagiarism and cheating will not be tolerated. Reasonable use of AI tools (e.g., ChatGPT) on homework is allowed but must be disclosed — explain what, how, and where it was used. AI use is not permitted on quizzes or exams.

Plagiarism and cheating result in an F for that assignment and referral to the academic misconduct committee. A finding of academic dishonesty may lead to penalties ranging from admonition to an F in the course and/or expulsion. When in doubt, ask the instructor.

Course Evaluation (SPOT)

Student Perceptions of Teaching (SPOT) is UNT's student evaluation system, allowing students to confidentially provide constructive feedback. Please complete evaluations at the end of the semester.

Syllabus Change Policy

Any changes to this syllabus, made only in extraordinary situations, will be clearly communicated to students.

Prohibition of Discrimination, Harassment & Retaliation (Policy 16.004)

UNT prohibits discrimination and harassment based on race, color, national origin, religion, sex, sexual orientation, gender identity, gender expression, age, disability, genetic information, veteran status, or any other characteristic protected under applicable law, across admissions, educational programs, employment, and university facilities. The University takes active measures to prevent such conduct and investigates and remediates as appropriate.

Emergency Notification & Procedures

UNT's Eagle Alert system notifies students quickly in the event of an emergency (severe weather, campus closing, chemical spills, fires, violence, etc.). Refer to CANVAS for contingency plans covering course materials.

Action item: Email the instructor before August 21, 2026, after reading this document, to receive partial credit.