MTSE 3040 Section 003 - Transport Phenomena in Materials (Fall 2023 1)

I. Course Structure

Instructor Contact

- **Name:**   Prof. Srinivasan Srivilliputhur
- **Office Location:**   Discovery Park C-136C
- **Phone Number:**   (940) 369-8273
- **Class Website**   Lecture notes, assignments, and quizzes will be posted on CANVAS
- **Lecture**   Tue/Thu 11:30 AM – 12:50 AM, DP D201
- **Office Hours:**   Wednesday 3 PM or by appointment.
- **Email:**   **srinivasan.srivilliputhur@unt.edu**
  (mailto:srinivasan.srivilliputhur@unt.edu)

Course Structure

The course will be in-class but the Office-Hours will be held on Zoom. Participation in the class during lectures is mandatory. The quizzes and homework must be submitted as a PDF file on CANVAS.

Textbooks

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

Tentative Topics

(A) Molecules in Motion: Concepts & Definitions.

  I. Maxwell-Boltzmann distribution.
 II. Collision frequency.
III. Transport processes and their coefficients.
   1. Diffusion, mass diffusivity.
   2. Heat flow, thermal conductivity.

(B) Chemical Reaction Kinetics.

  I. Homogeneous & heterogeneous reactions.
 II. First and Second order rate equations.
III. Multi-step reactions.
 IV. Calculating rate constants: from collision theory & Arrhenius equation.
  V. Applications of materials kinetics.

(C) Mass Transport Kinetics (Diffusion).

 I. Fick's First and Second Laws.

  1. Conservation of mass; divergence theorem.

  2. Steady-state and transient solutions.

  3. Experimental determination of D, the mass diffusivity.

 II. Atomic mechanisms.

  1. Defects and diffusion.

  2. Relation of random walk to D; Einstein-Smoluchowski equation.

  3. Low-temperature short circuit diffusion – dislocation pipe and grain boundaries.

  4. Arrhenius ln(D) versus (1/T) plots extending to low temperatures.

  5. Point defects in ionic solids

   - Kröger-Vink notation.
   - Defect reactions.

  6. Ionic conduction and its relation to diffusion.

   - Einstein equation.
   - Effect of doping on the ion transport in solids.

III. Multi-component diffusion.

   1. Kirkendall Effect and moving interfaces.

   2. Darken's equations.

   3. Boltzmann-Matano solution.

(IV) Heat Transport Kinetics (Conduction): Analogy with diffusion.

(V) Viscosity of Liquids.

(VI) Application of Diffusion in Material Processes

 1. Diffusion in crystals and nanocrystalline materials.

 2. Motion of dislocations, surfaces, and interfaces.

 3. Kinetics of phase separation.

Specific Course Information

a) <u>Prerequisites</u>: MATH 3410, MTSE 3000.

b) <u>Indicate whether a required, elective, or selected elective course</u>: Required

c) Upload your assignments and quizzes on CANVAS. Emailed answers are NOT acceptable.

Specific Goals: This course addresses ABET Student Outcome 7

a) Specific outcomes of instruction

1.   Understanding how molecular motion triggers rate processes in materials.

2.   Learn about rate processes in chemical kinetics and solve illustrative problems.

3.   Solve mass transport problems in materials processing with Fick's laws of diffusion and equations of mass balance.

4.   To learn materials processing technologies and the application of theory in these technologies.

b) Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.

II. Important Class Policies

1. CANVAS will be used primarily for posting announcements, lecture slides, assignments, and solutions.
2. **Office hours** will be used to guide you on homework assignments and answer/clarify your questions.
3. **Five homework** assignments will be assigned throughout the semester to illustrate concepts taught in the class. Assignment problems will involve graphing and solving differential equations. I expect you to use computational software like R to answer assignments and have provided tutorial videos. You may also use MATLAB or Mathematica, but cannot expect my help with them. Many prefer Excel spreadsheets, but they are tedious to use for scientific computation and plotting relevant to this class.
4. **Homework problems are often challenging. I will guide you to solve them during office hours if you need help. But, you must attempt them first.**
5. **Two or three exams** *will be administered in class after the due announcement.* Each exam <u>may</u> contain multiple-choice, short-answer, and quantitative questions/problems. There will be an in-class exam review during the lecture prior to an exam.
6. Efforts will be made to grade your exams within two weeks after they are due. *Late homework assignments and exams will NOT be accepted.*
7. You are allowed to use <u>only</u> a calculator, pencils, pens, and erasers in your quizzes and exams. **Earphones, cell phones, laptops, smartwatches, and other devices are banned.**

8. Lectures will cover the theory of rate phenomena. Often during each Wednesday lecture, I will present a problem that illustrates the theory. Students will try to solve it during the class period. I will present a discussion and solution during my office hour on Thursday.

Grading rubrics

- Homework Average 40% (five assignments; 8% each)
- Exams   60% (three exams; 20 % each)

Final Grades

Final grades are curved and will be determined based on the following:

- **A** >= 90%; **B** >= 80 and < 90%; **C** >= 70 and < 80%; **D** >= 60 and < 70%; **F** < 60

Makeup Exam Policy: *Makeup exams are allowed only for mitigating circumstances such as business travel, a serious illness of a student, or a close family member.* A student facing such situations must notify the instructor *via email* and provide documentation such as a doctor's note etc.

Class Attendance is Mandatory.

Optimal learning demands regular class attendance and active listening/participation in classroom discussions. Please notify the instructor in advance if you have to miss a class or will be late. While traffic and other issues present difficulties, being more than 15 minutes late for class regularly is disruptive and unacceptable. 10 or more unexcused absences will lead to a student being dropped from the class.

Calculators   You may use a scientific calculator but **cannot share it with classmates.**

Your calculator must be able to find the value of *trigonometric (SIN, COS, TAN), exponential (e^x), power (x^y), square root, natural log (LN), base 10 log (LOG), inverse functions, and plot graphs.*

Cell Phone Usage Policy   Cell phones and other electronic communication devices cannot be used and must remain "out-of-sight", during class time. **Texting, online activity, messaging, playing games, etc. during class time is prohibited. <u>Students violating this policy will be asked to leave the class</u>.**

Disabilities Accommodation

UNT complies with Section 504 of the 1973 Rehabilitation Act and with the Americans with Disabilities Act of 1990. It provides reasonable accommodation and auxiliary aids to individuals with disabilities, as defined under the law. If you believe you have a disability requiring accommodation, please contact the Office of Disability Accommodation at 940-565-4323 *during the first week of class*.

Authorized Absences and Extenuating Circumstances

Excused absences include illness, conference travel, participating in university-sponsored activities, family emergencies, religious holidays, and any other unplanned difficulty as determined by the instructor. Absences must be verified by the Dean of Students, doctor's note, etc. Consideration of such absences will be made for quizzes and examinations, but not for homework. For participation in sponsored activities, a student must seek approval prior to their absence. For absences due to extenuating circumstances, you have 1 week to contact the instructor to begin the process.

Absence During Religious Holidays

The state law allows a student that is absent due to the observance of a religious holiday to take examinations or complete assignments scheduled for the day(s) missed, including those missed for travel, within a reasonable time after the absence. Only holidays or holy days observed by a religion whose place of worship is exempt from property taxation under Section 11.20 of the Tax Code are eligible. You must notify the instructor of the date(s) of anticipated absence before the end of the 2nd week after the semester starts.

Statement of Expectations for Student Conduct and Academic Integrity

Consult UNT's academic manual for the relevant policies and procedures. The students must conduct themselves in a professional manner, and be honest and ethical in their academic work. *Academic dishonesty such as plagiarism and cheating will NOT be tolerated.* Academic dishonesty is defined as an intentional act of deception in one or more of the following areas:

- **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 any information
- **Plagiarism** – representing the words or ideas of another person as one's own.
- **Tampering** – altering or interfering with evaluation instruments and documents

Student(s) violating these policies will receive an overall **F grade (Fail)**. In addition, such violations will be forwarded to university administrators for additional punishments/sanctions. When in doubt, ask me.

Email me after reading the above instructions to get credit for your assignment-1.

Course Evaluation

Student Perceptions of Teaching (SPOT) is the student evaluation system for UNT and allows students the ability to confidentially provide constructive feedback to improve the quality of learning in the course. Please fill out the evaluations at the end of the semester.

Syllabus Change Policy

Any changes to the syllabus (in an extraordinary situation) will be clearly communicated to the students.

Prepared by: Srinivasan G. Srivilliputhur, August 17, 2023.

Course Summary:

Date	Details	Due
Sun Sep 17, 2023	📝 **Homework#1 (https://unt.instructure.com/courses /92987/assignments/1904117)**	due by 11:59pm