MET 422 SYLLABUS

MET 422 TRANSPORT PHENOMENA

(4-0) 4 credits. Prerequisite: MATH 321 and concurrent enrollment in MET 320. The principles of momentum, heat and mass transfer and their application to metallurgical engineering. Topics covered include thermal conductivity, mass diffusion, mechanisms of transport, Fourier's and Fick's Laws, shell balance, boundary conditions, equations of change, unsteady-state transport, mass and heat distributions in turbulent flow, and interphase transport.

TEXTS

G. H. Geiger and D. R. Poirier, Transport Phenomena in Metallurgy, Addison-Wesley Publishing

INSTRUCTOR

Dr. S. M. Howard MI 114 Ph. 394 -1282
Stanley.howard@sdsmt.edu Open Office Policy

REQUIRED/ELECTIVE

MET 422 is required for all B.S. Metallurgical Engineering. It is a required course for B.S. Environmental

COURSE OBJECTIVE

Students who satisfactorily complete this course will be able to determine velocity profiles in laminar flow systems, drag forces in turbulent flow systems, unsteady-state temperature profiles in isotropic simple solids, heat fluxes through boundary layers, net heat fluxes among gray surfaces from radiation, mass transfer rates across interphase boundaries.

COURSE OUTCOMES

- Students are expected to write Newton's Law, Fourier's Law, and Fick's Law and describe the analogies among them.
- Students will perform shell balances for momentum, heat, and mass transfer and obtain the differential equation describing the velocity, temperature, and concentration gradient.
- Students are expected to understand the difference between Newtonian and non-Newtonian flows.
- Students will be able to reduce the Equations of Continuity and Change for rectangular, cylindrical and spherical coordinates to the terms applicable for a specified condition.
- Students will be able to derive from linear, steady-state flow distributions in laminar flow volumetric and average flow equations.
- Students will be able solve ladle draining and incompressible pumping problems involving all five terms in the Overall Energy Balance.
- Students provided a set of independent variables upon which a dependent variable depends will reduce the set to a dimensionless set using Buckingham Pi Theory.
- Students will be able to design packed and fluidized beds for given system for uniform particles given their density, shape, and size and the fluid's rheolgical properties.
- Students must determine the modes of heat transfer (conduction, convection, and radiation) and describe the governing equations for each mode.
- Students are expected to calculate the heat transfer rate for convective heat transfer given heat transfer correlation and its pertinent parameters.
- Students will determine heat loss from radiative systems using Kirchoff Loop electric analog solution method.
- Students will solve 1D USS and 2D SS heat transfer and mass transfer problems using spreadsheets.
- Students will determine the concentration dependency of diffusivity.
- Students will be able to derive differential equations describing diffusion through a stagnant gas film, a moving gas stream, and a falling liquid film.
- Students will describe the mathematical similarities between turbulent convective heat transfer and turbulent diffusion including the correspondence between dimensionless groups.

CLASS SCHEDULE

11:00 – 11:50 MWF MI 220

MET 422 SYLLABUS

TOPICS

• Introduction to momentum, energy and mass transfer analogies between Newton's, Fourier's, and Fick's Laws	(1)
• Theoretical and semi-empirical equations for viscosity of gases, liquids, and molten slags	(3)
• Newtonian and non-Newtonian fluids	(1)
• Laminar flow and momentum balances: flow of a falling film; flow through a circular tube	(3)
• Equations of continuity: rectangular volume	(2)
• Substantial time derivative; total and partial time derivatives	(2)
• General equations of momentum transfer: Navier-Stokes, Euler equations	(2)
• Applications of the general equation of motion: flow through a long vertical cylindrical duct	(1)
• Creeping flow around a sphere; flow near the leading edge of a flat plate	(1)
• Dimensional analysis: Re, Fr numbers	(1)
• Turbulent flow: time-smoothed quantities Interphase transport: friction factor	(2)
• Flow through packed and fluidized beds	(4)
• Theoretical and semi-empirical equations for thermal conductivity of fluid and solids	(1)
• Heat conduction flat plates, cylinders through composite walls with generation	(4)
• Heat transfer with forced and natural convection	(4)
• Transient systems	(2)
• Solidification heat transfer	(2)
• Radiation Heat Transfer	(5)
• Dimensional analysis: Nu, Gr numbers	(1)
• Molar and mass flux Theoretical and semi-empirical equations for diffusivity of gases, liquids and ionic species	(3)
• Diffusion in solids of gas through thin film, concentration dependent diffusivity transient diffusion	(3)
• Mass transfer in fluid systems diffusion through a stagnant gas film, diffusion in a moving gas stream, diffusion into a falling liquid film, forced convection	(2)
• Dimensional analysis: Sh, Sc numbers	(1)
• Reviews	(4)
• Hour Exams	(4)
	(59)

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES

a) Apply Knowledge of Math, Science, and Engineering
c) Optimally Select Material and Design Materials Treatment and Production Processes
e) Identify, Formulate, and Solve Engineering Problems

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT

- This course prepares students in the basics of transport Phenomena and, therefore, provides students with the necessary basis to design, operate and optimize metallurgical processes.
- Ethical and professional conducts are emphasized throughout the course and also emphasized is global awareness in engineering.

LABORATORY- None

ASSESSMENT AND EVALUATION

One Final Exam – required by all students
Three or Four Hour Exams
Homework

EXPECTATIONS

Metallurgical Thermodynamics
College Calculus, Chemistry, Physics

COMPUTER USAGE

Excel including VBA Macros

GRADING

Homework	25 points each	200*
Short quiz every day	10 points each	450*
3 or 4 Hour exams	100 points each	300 - 400
Final exam		150**

* These are approximate numbers based on previous sections.
** Sometimes the fourth hour exam is combined with the final.

The final grade is based directly on the total points achieved. There is no additional weighting. On rare occasions a student's grade may be raised (but never lowered) for subjective considerations such as an excellent homework file. The final grade section average is normally between 2.9 and 3.2.

POLICIES

- Students who are ill should not attend class or enter the MI Building. Use email and the telephone.
- All exams sheets provided by the instructor MUST be turned in on top of each exam.
- Some homework may not be graded but all homework must be kept in a bound notebook available for inspection.
- Students who wish to be excused should leave a message at 394-1282or email Dr. Howard at stanley.howard@sdsmt.edu before the absence. Excuses are allowed for sickness, emergencies, etc. Students who were unable to call before the absence occurred should discuss the absence but never in person when they are ill.
- No quizzes or exams are thrown out.
- Students who return from an excused absence may elect to write a one-page paper on the previous day's lecture in lieu of taking the short quiz the day of their return to class. The one page paper is due the second class day of the students return.
- Students returning from an absence who wish to receive an estimated grade for the assignments missed during an excused absence must submit on a separate full sheet of paper their request stating the dates for which they are requesting an estimated grade. Unexcused absences will result in a zero.
- Short quizzes will heavily emphasize the lecture material from the previous day.
- Students who miss an hour exam for an excused reason will be given a make-up exam but it will probably be more difficult and longer than the missed exam. Students are expected to take makeup hour exams within three days after their return from an excused absence.
- Dr. Howard has an open door policy.
- Dr. Howard's schedule is posted on the door to his office: MI114. Students are welcome to call Dr. Howard at 394-1282 or email him at stanley.howard@sdsmt.edu concerning class questions. Appointments are discouraged unless there is a significant reason to make one. Special arrangements can be made to meet with a student with a schedule that makes it difficult to meet during regular working hours.
- The 30 minute period before an hour exam is generally not a good time to ask questions since it is reserved for exam writing and printing.

PREPARED BY

S. M. Howard