14:635:212 PHYSICS OF MATERIALS

Course Outline, Spring 2006

Miscellaneous Information

Class Hours:	Tuesday, Thursday 3:20 - 4:40pm, SEC-208
Instructor:	M. J. Matthewson
Office:	Engineering A133
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Web:	*www.rci.rutgers.edu/~mjohnm/classes*
Office Hours:	I operate an open door policy - if I am in I will be glad to talk to you. However, I also have formal office hours so that you know when you can find me in: Tuesday, Thursday 4:40 - 5:10pm, Monday, Wednesday 4:15 - 4:45pm, or by appointment.

Textbooks

There is no required textbook for this course. Chapters in the following books are useful: *The Production of Inorganic Materials* by Evans and De Jonghe (Macmillan, 1991), *Fundamentals of Ceramics* by Barsoum (McGraw-Hill, 1997), *Physical Ceramics* by Chiang, Bernie and Kingery (Wiley, 1997), *Introduction to Ceramics* by Kingery, Bowen and Uhlmann (Wiley, 1975). A collection of notes and example problems for this course will be distributed.

Grading

The grade for this course is made up of 4 problem sets (20%), 2 quizzes (40%) and a final exam (40%). Problem sets should be individual efforts but students are encouraged to help each other with hints. The quizzes and the final exam are all closed book. Calculators will be provided - if students want to use their own calculator, they must demonstrate clearing the calculator's memory at the start of the exam - please come early if you chose the latter. Students should bring graph paper and a ruler to all exams.

Schedule

Click here to see the schedule.

Course Outline

Viscous Flow
Elasticity: stress, strain, linear elastic behavior, elastic moduli. Viscosity: definition, temperature dependence, turbulence. Viscosity measurement: derivations from first principals, Poiseuille flow, Stokes flow, dimensional analysis, rotational viscometer, cone-plate viscometer, measurement by elastic analogy. Rheology: categorization of behaviors, example systems, suspensions.

Reaction Kinetics
Homogeneous and heterogeneous reactions, definition of reaction rate, dependencies, rate equations, reaction order, probabilistic interpretation, heterogeneous rates, reversible reactions, Langmuir, Langmuir-Hinshelwood, temperature effects, activated complex theory, Boltzmann distribution. Mass transport, rate controlling step.

Thermal Properties
Heat capacity & specific heat: equipartition theorem, gases, Debye theory. Thermal expansion: relation to heat capacity, reversibility, anisotropy, thermal stress, glazes. Thermal conductivity: phonon, electron, photon contributions, multiphases.

Heat Transfer
Conduction: Fourier's laws, steady state solutions, solution in one dimension, furnace wall, cylindrical symmetry, time dependent solutions, steady rate of heating/cooling, thin film solution, error function solution. Convection: forced & natural, solution by dimensional analysis, example of convection from long cylinders, heat transfer coefficient. Radiation: black body radiation, emissivity & absorptivity, Kirchoff's law, non equilibrium.

Temperature Measurement
Optical pyrometer. Thermoelectricity: Seebeck effect, Peltier effect, Thomson effect, thermoelectric power diagrams, practical measurement.

ABET A-O Requirements

A. Apply knowledge of mathematics, science and engineering
Students learn the fundamental physics that leads to many of the measurable physical properties of materials. They apply their mathematical and scientific knowledge to understand the derivation of key relationships of physical properties to the underlying physical processes controlling those properties.

B. Design and conduct experiments, as well as to analyze and interpret data
Students learn what experiments are needed to measure the physical properties of materials. They learn how to graph real experimental data and interpret the data in terms of the physical models. They learn how to review the data critically and to assess the significance and cause of any deviations from theory.

C. Design a system, component, or process to meet desired needs
The students learn how to apply their understanding of physical properties in order to make simple designs for relevant processes. They apply thermal conductivity principles to design furnace walls.

E. Identify, formulate and solve engineering problems
Students learn not only to understand the origin and nature of physical properties, but also learn how to apply their understanding to solving quantitative problems associated with those physical properties.

L. Use experimental, statistical, and computational methods to analyze the behavior of ceramic systems
Students learn how to determine physical properties of materials by making suitable graphs of experimental data. They learn how to fit a theoretical model to the data and extract values for the physical parameters. Particular emphasis is given to assessing the confidence of the measured values of the physical parameters.

M. Apply advanced science and engineering principles to materials systems
Students learn that the physical properties of materials can be related to their atomic structure, bonding, etc. They also learn how the physical properties affect the performance of a material in typical applications.

N. Understanding of the fundamental principles underlying and connecting structure, properties, processing and performance related to the material systems utilized in ceramic engineering
This course emphasizes that the physical properties of materials are related to fundamental physics. Reference is made to quantum mechanics and statistical mechanics where appropriate and is it shown how these principles provide understanding of why materials behave the way they do. Students learn why different classes of materials have very different physical properties.

O. Apply and integrate knowledge from each of the above four elements of the field to solve material selection and design problems
Throughout students are encouraged to relate all levels of understanding from the very basic physical principles through physical properties to the application of this knowledge to understanding real engineering problems. Students are shown that their understanding of at a fundamental level can help optimize the solution to an engineering problem or predict the behavior of a new material system.

Student Feedback

I take the comments made by students on the teaching assessment forms very seriously so that I can improve the quality of this course. Below I address issues raised by students the last time I taught this class:

More worked example problems:
I plan to approximately double the number of example problems worked in class. In addition, as we go through the semester I will hand out solutions to a selection of the example problems distributed at the start of the semester.

Use a Textbook / More notes:
Since this class covers a variety of topics not typically covered in one text book, there is no single class text. However, handouts are distributed for most of the material covered, but there are gaps. I will increase the number of handouts to more fully cover all the class material.

Please give me feedback on how I am doing with these improvements. Please do not wait until the end of the semester for the teaching assessment forms if you think I can usefully make changes immediately. Any and all constructive criticism will be gratefully received!

M. J. Matthewson, 060104.