

**Department of Materials Science and Engineering**  
University of Maryland, College Park, Maryland

**ENMA 463 Macroprocessing of Materials**

**Course Description:** Processing of modern, bulk engineering materials. Raw materials, processing, and characterization.

**Pre-requisites:** ENMA 300 or consent of instructor

**Textbook:** There is no single textbook that covers all the material at an appropriate level. We will use:

- J.S. Reed, Introduction to the Principles of Powder Processing, Wiley, 1995, 2nd. edition as our textbook since it covers powder processing well.
- Selected readings from Callister, Fundamentals of Materials Science and Engineering: An Integrated Approach 2<sup>nd</sup> Ed., John Wiley and Sons, 2003, ISBN 0-471-47014-7 (ENMA 300 text), R.A. Flinn and P.K. Trojan, Engineering Materials and Their Applications, 4<sup>th</sup> ed., John Wiley and Sons, 1995, other books, and the current literature will also be required.

**Course Objectives:** The objective of this class is teach students the types of processes required to make discrete engineering components, especially polycrystalline ceramic and metal components and engineering polymers. Processing and manufacturing are evolving areas so emphasis is placed on understanding what happens during process steps and the critical thinking skills necessary to effectively combine process steps in an overall process transferable to manufacturing. Students satisfactorily completing the class will:

1. Understand and be able to apply the design of experiments/fractional factorial approach to designing experiments and processes.
2. Be familiar with modern and more traditional approaches to process "discrete" or "bulk" products and materials via solid state and melt based routes.
3. Understand the similarities between processing various classes of materials (metals, ceramics and polymers) as well as the differences.
4. Be able to identify the relationships between a processing method and resultant properties and microstructure.

**Topics Covered:**

- I. Introduction: Why is processing important? How are processing and manufacturing related? Solid state vs. melt processing.
- II. The design of experiments or fractional factorial approach: How can we optimize a set of experiments to maximize the ratio of pertinent information/resources expended or optimize a process to make consistent, high quality products?
- III. Raw materials: What kinds of raw materials are used to produced metals, ceramics, polymers and composites? How can desirable components of raw materials be separated from undesirable components.
- IV. Melt based methods: casting, injection molding, etc.
- V. Solid state methods
  - A. Deformation processing: forging, drawing, extrusion, etc.
  - B. Powder processing
    1. Powder preparation: traditional (size reduction – calcination and grinding) vs. modern (particle growth – wet chemistry)
    2. Shaping: pressing and slurry based approaches
    3. Sintering: solid state and liquid phase sintering

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- VI. Composites: How do you process mixed systems where the materials have different properties (bonding, density, size, shape, hydrophobic vs. hydrophilic etc.)?
- VII. Characterization: chemical, physical, microstructural

**Class Schedule:** Tuesday, Thursday 9:30-10:45 a.m. in CHE 2118

**Grading:**

Termpaper	20%	(due Tues Nov. 25, 2008; topic due Sept. 9, 5 possible references <b>AND</b> outline <b>OR</b> abstract due Sept. 23)
TP Presentation	8%	8 min. + 2 min. questions (after Thanksgiving break)
Midterm	22%	Thurs. Oct. 13, 2005, tentative date
Final Exam	35%	Tues. Dec 16, 2008, 8:00 am – 10:00 am ( <b>Sched. Classes</b> )
Homework	15%	

Homework is intended to give students a chance to practice with concepts and critical thinking skills in an environment where mistakes are not "costly". Homework will include traditional written problem solving assignments and short reports on the application of processing principles and techniques in industry. While general concepts may be discussed with classmates, homework is **NOT** to be a team effort unless specified.

**Academic Integrity:** <http://www.studenthonorcouncil.umd.edu/code.html>

**Course Website:** <https://bb.eng.umd.edu> (ENMA 463)

**Instructor:** Dr. Isabel Lloyd                      2309C CHE (Bldg 090)  
**Tel:** 301-405-5221                                      email: [illoyd@umd.edu](mailto:illoyd@umd.edu)

**Office hours (tentative):** Tues. 11 am-12 noon, 5:00-5:30 pm, Thurs 1-2 pm and by appointment

**Course Goals to meet ABET 2005 Criteria:**

1. Students apply design of experiment techniques to process development.
2. Students understand similarities and differences between processing different classes of materials
3. Students will be able to identify relationships between processing techniques and resultant material microstructure.
4. Students will prepare a written and oral presentation on an issue in modern materials processing.
5. Green processing

**Contribution of the course to meeting the professional component:**

This course introduces design of experiments and it emphasizes application of the concepts covered to production of real materials. It also requires the students to consider the costs (both environmental and monetary) associated with various types of processes. The problem solving/critical thinking skills as well as the specific knowledge gained are a basis for future professional development.

**Relationship of the class to the program objectives**

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This course is a required course. It teaches students the basic information that they will need to understand and design the production of products or components via non-vapor phase techniques.

### **Termpapers:**

Your termpaper should emphasize the solid state or liquid phase processing of a material. The consequences/results of the processing method(s) explored in terms of properties and applications **should** be included, but processing **MUST** be the main focus.

You may choose a topic related to a job or thesis, but, you may NOT choose a topic central to your job or thesis. Topics must be approved ahead of time (see grading).

### **Specifics:**

- The paper should be about 15 pages.
- The paper should contain about 5-20 references, with at least 3 current ( $\geq 2004$ ) journal articles. While your references may include review articles, textbooks, and the internet, they should be primarily refereed, archival journal articles. If you use "news release" type references you should 1) indicate that they are unrefereed, 2) analyze the content in the context of publicity information, and 3) severely limit the number of such references.

### **General Format (All papers must include the following)**

1. Title page with an abstract or executive summary (your topic and your main "conclusions").
  - Less than 1 page
  - The ability to succinctly state what you have done (approach, actions and results) and why it matters is a critical skill in the "real world".
2. Table of Contents (Number each page in your paper)
3. Introduction (1-2) pages
  - What will be discussed in your paper in general terms.
  - Why it is important to industry, to science, and/or to the public.
  - Where it is used.
4. Body (12-14 pages)
  - Survey and analysis of the literature on your topic. Evaluate what you read and "tie" it together. Annotated bibliographies are not acceptable. You should be comparing and contrasting the information from your sources and analyzing what it means.
5. Summary
6. References (Authors, title, volume, pages and source). I prefer Journal of the American Dental Association or Journal of the American Ceramic Society style.

### **Credit for sources:**

- When you copy a figure, table, graph, etc., include the source in your figure caption to make sure that it is properly attributed. (Remember you would need permission to use them if you were writing a paper for publication.)
- In the body, make sure you attribute ideas as well as data.  
For example: Lloyd [1] found that tiger snails travel at 10 mm/hr while Liu [2] found that tiger snails travel at 5 mm/hr. The difference is attributable to the different subspecies studied. Both results validate Smith and Jones' theory [3] on snail locomotion. This theory ...

**Note:** Please make sure you understand the information you include and discuss. It is dangerous to include material you don't understand since that is usually where questions are pointed. It also tends to lower your credibility with respect to the rest of the paper.

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June 12, 2008