MATSE447 Fall Semester 2011

Polymer Rheology and Processing

MWF 2:30 pm, 104 Steidle Bldg.

Professor Evangelos Manias, 325 Steidle Bldg.
863-2980 manias@psu.edu

Office Hours: MW 1:30 - 2:30 pm; TR *by appointent*

TEXT: J. M. Dealy and K. F. Wissbrun, **Melt Rheology and its Role in Plastics Processing**, Kluwer Academic (1999) ISBN 0 412 7391 0

Syllabus

I. Basic Fluid Mechanics (3 weeks)

Stress, strain, tensors, viscosity, modulus, conservation of mass, momentum transfer, Navier-Stokes equations, Reynolds number, creeping flow, Poiseuille flow, Couette flow, dimensional analysis and scaling.

II. Rheology (8 weeks)

Linear viscoelasticity, stress relaxation, oscillatory shear, creep and creep recovery, Boltzmann superposition, nonlinear viscoelasticity, steady shear, normal stresses, transient shear flows, rotational rheometers, capillary/slit rheometers, simple nonlinear viscosity models, time-temperature superposition, molecular models, entanglement, concentration effects, crosslinking reactions (gelation), extensional flows.

III. Processing (4 weeks)

Extrusion, pumping, mixing, screw design, die design, die swell, injection molding, mold filling, computer-aided mold design, weld lines, compression molding, sheet extrusion, thermoforming, pipe extrusion, blow molding, film blowing, rotational molding, fiber spinning, profile extrusion, coating, reaction injection molding.

MATSE447 **Assignments & Grading**

There will be 6 to 9 **homeworks** (depending on class progress and performance). There will be 3 **in-class exams**, and a written **final exam**.

All homeworks are due at the start of class (2:30 pm) on the pre-assigned day. The three in-class exams will be during scheduled class times (MWF 2:30 – 3:20 pm)

Grading

25% Homeworks	25% Exam #1	25% Exam #2
25% Exam #3	25% Final Exam	(Total: 125%)

We **drop the lowest exam** score relative to the mean.
Grading is done with an excellent score corresponding to 100%.

TAs (all three in 316 Steidle Bldg.)
<none>

Students are encouraged to collaborate and work jointly to complete homework assignments (you may hand in collaborative homeworks for **teams up to 3 students**). Students are also encouraged to seek homework help **from their professor**.

Students must work independently on all examinations.

See http://www.psu.edu/ufs/policies/ for our expectations regarding Academic Integrity.

Prerequisites

MatSE443 (Introduction to Polymers), CALCULUS, and PHYSICS

Two Hour Reserve Books (Deike Library)

RHEOLOGY

F. N. Cogswell, *Polymer Melt Rheology: A Guide for Industrial Practice* (1997).
J. D. Ferry, *Viscoelastic Properties of Polymers* (1980).
C. W. Macosko, *Rheology* (1994).
F. A. Morrison, *Understanding Rheology* (2001).
R. W. Whorlow, *Rheological Techniques* (1992).

PROCESSING

A. W. Birley, B. Haworth and J. Batchelor, *Physics of Plastics: Processing, Properties and Materials Engineering* (1992).
S. Middleman, *Fundamentals of Polymer Processing* (1977).
D. H. Morton-Jones, *Polymer Processing* (1989).
T. A. Osswald, *Polymer Processing Fundamentals* (1998).
Z. Tadmor and I. Klein, *Engineering Principles of Plastics Extrusion* (1970).

TEXT

J. M. Dealy and K. F. Wissbrun, *Melt Rheology and its Role in Plastics Processing* (1995).

Melt Rheology and its Role in Plastics Processing
JOHN M. DEALY and KURT F. WISSBRUN

1. Introduction to Rheology (40 pages, Exam#1)

2. Linear Viscoelasticity (58 pages, Exam#1)

3. Introduction to Nonlinear Viscoelasticity (47 pages, partially covered, Exam#2)

4. Steady Simple Shear Flow and the Viscometric Functions (24 pages, Exam#2)

5. Transient Shear Flows Used to Study Nonlinear Viscoelasticity (50 pages, Exam#2)

6. Extensional Flow Properties and Their Measurement (35 pages, Exam#3)

7. Rotational and Sliding Surface Rheometers (25 pages, Exam#2)

8. Flow in Capillaries, Slits and Dies (43 pages, Exam#2)

9. Rheo-Optics and Molecular Orientation (18 pages, skipped)

10. Effects of Molecular Structure (24 pages, Exam#1and2)

11. Rheology of Multiphase Systems (18 pages, skipped)

12. Chemorheology of Reacting Systems (20 pages, skipped)

13. Rheology of Thermotropic Liquid Crystal Polymers (15 pages, skipped)

14. Role of Rheology in Extrusion (48pages, partially covered and supplemented from Birley, Haworth and Batchelor, Physics of Plastics: Processing, Properties and Materials Engineering (1992) and Tadmor and Klein, Engineering Principles of Plasticating Extrusion, Exam#3)

15. Role of Rheology in Injection Molding (16 pages, supplemented from Middleman, Fundamentals of Polymer Processing, Exam#3)

16. Role of Rheology in Blow Molding (20 pages, Exam#3)

17. Role of Rheology in Film Blowing and Sheet Extrusion (25 pages, partially covered, Exam#3)

18. On-Line Measurement of Rheological Properties (8 pages, skipped)

19. Industrial Use of Rheometers (32 pages, skipped)

ADDITIONAL SUBJECTS

Coating Thin Films from Solution (see Middleman book, Final Exam)

Profile Extrusion (Final Exam)

Reaction Injection Molding (see Macosko, Fundamentals of R.I.M., Final Exam)

Rotational Molding (Final Exam)

Wire Coating (see Middleman book, Final Exam)