Polymer Processing Course Summary:

Background

1) Overview of polymer processing industry.
2) The plasticating extruder and other processing equipment. (Parts/Terminology)
3) Constitutive Equations
4) Tensile versus Shear stress/strain/strain rate.
5) Chain Entanglement.
6) Typical viscosity versus rate of strain curve (terminology)
7) Zero shear rate viscosity versus MW
8) Relaxation, Deborah number
9) Operating window
10) Glass transition, DMTA, Arrhenius Behavior of viscosity
11) Molecular weight distribution.

Lab 1: Couette Viscometer

1) Couette viscometer equations
2) Power-Law Fluids
3) Arrhenius behavior of viscosity
4) Molecular weight dependence of viscosity
5) WLF equation
6) Poiseuille equation and melt index measurement.

Lab 2: Plasticating Extruder

1) Die Swell and Normal Stress
2) Melt Fracture and shark skin
3) Residence time
4) Poiseuille Flow for parallel plates Q_p, Q_d.
5) Isothermal versus adiabatic analysis.
6) Poiseuille Flow for a tube (die).
7) Prediction of die swell.
8) Molecular weight distribution and die swell.

Chapter 2

1) Continuity Equations, Dynamic Equations
2) Tensor description of stress, strain and rate of strain
3) Tensor invariants
4) Normal stresses, hydrostatic pressure
5) Lubrication Approximation and Reynold's Number
6) Reynold's Equation

Lab 3: Fiber Spinning

1) Terminology
2) Velocity profile for constant elongational strain rate (be able to derive)
3) Diameter profile as a function of z.
4) Relationship of die swell to fiber spinning.

5) Axial stress equation problem 9-4 + reasoning for this equation.
6) Calculation of draw-down ratio.
7) Explain why heat transfer is the limiting step in almost all polymer processing operations.
8) Uniaxial orientation.
9) Simple uniaxial extensional flow.

Chapter 3

1) Examples (pictures) of polymer melt rheology, Wiessenberg effect and others.
2) Arrhenius behavior, WLF behavior
3) Constitutive equations for generalized Newtonian Fluids
    - Power law fluid
    - Bingham fluid
    - Newtonian fluid
    - Carreau Model
4) Normal stress equations
5) Viscometric Flows
6) Capillary Rheometer, Poiseuille Equation
7) Couetter Viscometer
8) Cone and Plate Viscometer
9) Elongational Flow, Trouton viscosity
10) Lodge Liquid, what is required for normal stress development: melt elasticity

Lab 4: Film Blowing

1) Terminology list.
2) Biaxial orientation.
3) Relationship between crossed polars and orientation.
4) Relationship between XRD pattern and orientation.
5) Simple biaxial extensional flow, mass balance.
6) Bubble pressure equation 10.20
7) BUR D_R be able to use in calculations.

Lab 5: Mixer Lab

1) General behavior of Torque, Power, Temperature versus goodness of mixing. Where is mixture mixed on these curves?
2) Scale of segregation
3) Intensity/Mixing Index
4) "F curve"
5) Relationship between surface area and accumulated strain and scale of segregation, goodness of mixing.

Lab 6: C-Mold Lab

1) Terminology of injection molding
2) Cycling involved this semi continous process
3) Where is viscous heating most likely to occur in an injection molding process

4) What is the main factor limiting the process (heat transfer and details of what happens when this is too high or too low.
5) General feel for how injection molding program works.
Lab 7: Injection Molding)
1) Terminology
2) Processing window for injection molding and problems associated with developing at processin window.
3) General idea of how to calculate the fill time and fill pressure for simple molds (Middleman problems).

Chapter 4

1) Binomial Distribution
2) I and M
3) Scale of segregation, how it is calculated.
4) R(r)
5) Details of the stripped texture, i.e. equations.
6) Residence time distribution functions for batch and continuous mixers.
7) Details of two chamber mixer and parallel plate mixer.
8) Mean strain
9) Mean residence time
10) CSTR equations

Lab 8: Coating

1) Meniscus Profile
2) Entrainment and Coating thickness
3) Capillary number
4) Roller coating sketch and flows.
5) Problems encountered with coating process in the lab.
6) Agreement between lab process and Middleman prediction for entrainment and coating thickness.