

ME-678-102

Tuesday: 6:00 PM - 9:05 PM, MEC 219

INSTRUCTOR: Dr. K.A. Narh, 330 MEC
 Phone: (973) 596-3353
 Email: narh@njit.edu

TEXTBOOK: Engineering Design with Polymers and Composites, James C. Gerdeen, Harold W. Lord and Ronald A.L. Rorrer (2006); ISBN: 0-8247-2379-1

REFERENCE BOOKS

1. Plastics Product Design and Process Engineering, Harold Belofsky, Hanser/Gardner, (1995)
2. Moldflow Design Guide by Jay Shoemaker (Ed.)
3. Plastics Part Design for Injection Molding by R.A. Malloy, Hanser/Gardner
4. Mechanical Properties of Polymer and Composites, L.E. Nielsen and R.F.Landel, Mercel Dekker, Inc.1994
5. Design and Manufacture of Plastic Parts, R.L.E. Brown, John Wiley & Sons, New York, 1980
6. Principles of Polymer Engineering, by N.C. McCrum, C.P. Buckley and C.B. Bucknall.

For some useful simulations on characteristics of Polymers, Check out the following Case Western Reserve University website: <http://plc.cwru.edu/tutorial/enhanced/main.htm>

HOMEWORK: About 6 in total. Homework assignments are usually due one week after being issued. Late homework will not be accepted except in the case of an excused absence. Solutions will be posted. There will be an afternoon or evening review session scheduled (some time before each exam) in which the homework problems will be discussed.

FINAL GRADE: Course average is based on term paper, exams, homework and a design project Report.

<u>Item</u>	<u>Weight (%)</u>
Exam 1	20
Term Paper/Mid Term Examination	20
Homework	10
Design Project	30
Final Examination	20

GRADING SCALE: The grading scale will be as follows: A (90-100); B⁺ (85-89); B (80-84); C⁺ (75-79); C (70-74); D (56-69); F (≤ 55)

CLASS RULES: Late Homework submissions NOT ALLOWED.
 Sleeping in class unacceptable.
 TURN OFF ALL CELL PHONES

NJIT STUDENT HONOR CODE

THIS WILL BE STRICTLY ENFORCED. ANY VIOLATIONS WILL BE REPORTED TO THE DEAN OF STUDENTS.

NOTE: All the above items may be subject to change on the instructor's discretion.
 (For example, the Grading Scale may be adjusted to reflect the class average.)

COURSE DESCRIPTION AND OBJECTIVES

This is a project-based graduate course which not only introduces the student to the unique properties of the various commercial thermosetting and thermoplastic resins but also the opportunity to design and analyze the manufacturability of plastic products using the available commercial computer software.

The Catalog description for this course has been thoroughly revised to take into account recent trends in plastics design. In particular, the course introduces the student to concurrent engineering practices used in designing and manufacturing injection molded plastic products. The use of a commercial computer aided design (CAD) and/or a computer aided engineering (CAE) software to perform design and process iterations on high speed computers, testing variations of part design, material selection, tool design and process parameters for injection molding, will be reviewed. It is anticipated that students who complete the course will understand and appreciate various processing techniques, and be able to exploit high performance computing tools for design and process optimization of injection molded products.

Pre-requisite

A background in plastic materials or plastics processing techniques is an advantage but not a pre-requisite for this course.

Students must be able to use Pro/Engineer (or IDEAS) for drawing CAD models.

All students will be first trained on the use of MOLDFLOW, a computer aided engineering (CAE) software for simulation of plastic product manufacturing by injection molding process.

Course Syllabus

Week	TOPICS	Reading Material
1,2	Introduction/Overview to Plastics Definitions and Classifications Thermoplastics, Thermosets, Elastomers (Rubbers): Family Characteristics Special Systems: Liquid crystalline polymers, Copolymers (random, block, graft), Polyalloys (blends and alloys); Cross-linking Physical States and Transitions: States: Melt; Solid; Crystalline State, Amorphous (Glassy and Rubbery States): Crystallinity and its Measurement Thermal Transitions: 1) Glass Transition Temp. T_g ; 2) Melting Temp. T_m Molecular weight and molecular weight distribution. Measurements of T_g and T_m	Chapter 1 Chapter 1: Chapter 1 Belofsky Chapter 4
3,4	Mechanical Properties of Solid Polymers Time-Independent Properties: short-term Properties: Tensile Properties; Stress-Strain Relations; Flexural, Compressive, Shear, Hardness. Factors Affecting Short-Term Properties: Temp, Strain Rate, MW, Cross-Linking Time-Dependent Properties: Short Term Properties: Impact Properties; Fracture Mechanics of Polymers Long Term Properties: Creep/Stress Relaxation; Fatigue Additives and Modifiers - Effect on properties. Composites - reinforcing fibers, Mechanics of fiber reinforcement	Chapter 2 Chapter 6 Chapter 4
5	Viscoelasticity: Creep/Stress Relaxation (Details), Mechanical and Models. Non-Mechanical Properties: (a) Thermal Properties (b) Optical, Electrical and Environmental Properties	Chapter 3 Chapter 6 Belofsky Chapter 6
6	EXAM 1	
7	Fundamentals of Melt Rheology: Classification of fluid behavior, Generalized Newton's Law of Viscosity, Effect of temperature and pressure on melt viscosity, Effect of molecular weight and MWD on viscosity, Viscosity, Temp, free volume & WLF Equation, Power Law fluids, Flow models: How to interpret rheology graphs	Belofsky Chapter 7
8	PROCESSING GUIDE (with focus on Injection Molding) 1) A Video on Manufacturing of Plastics Products: Extrusion, Blown Film Extrusion, Blow Molding, Injection Molding, Compression Molding, Transfer Molding Thermoforming, Rotational Molding. 2) Focus on Injection Molding: Process Overview: The Injection Molding Machine: Process Procedure: The process Cycle: Mold Filling, Mold Packing, Cooling, Ejection, Flowability; Product Description; Mold Design: Basic Geometric Requirements, Gating: Gate Types, Location. Runners: Balancing (Shear versus Pressure), Flow Length, Venting, Mold cooling..	Also Belofsky Chapters 9 Chapter 9
9	The Design Process: Guidelines for Material Selection, Process Selection, and Product Design Introduction to MOLDFLOW	Chapter 7
10-13	EXAM 2/TERM PAPER Design Project: Computer Lab	MOLDFLOW
14	Project Reports and Oral Presentation	
15	Final Examination	

NOTE:

The reading assignments for the textbook are listed in the syllabus. Unfortunately, there are topics that will be covered that are not covered as well as I would like or are not covered at all. I will supplement the textbook material via lectures, reference books, and via handouts of additional material. Students will be contacted before any changes are made to the above syllabus.

A. TERM PAPER (Alternative to EXAM #2)

Write a Term Paper on the following Topic. Reports due by **March 23, 2010**.

Scientific Observation: “Nanoparticles tend to form massive structures of highly sintered aggregates or bundles which make it difficult, if not impossible, to disperse homogeneously in viscous fluids, especially thermoplastic melts, in order to create nanocomposites with superior mechanical, thermal and electrical properties”.

Write a Term Paper on “Experimental Methods for De-clustering Nanoparticles”.

At least 6 Literature papers must be critically reviewed on the above subject. These papers must not be older than 1995 (this condition will be waived for exceptionally good old journal papers). Read papers dealing with the preparation of polymer based nanocomposites or de-aggregation, deagglomeration, or de-clustering of nanoparticles. Your term paper must contain:

- Abstract
- Introduction
- Experimental (Various experimental methods for preparation of polymer nanocomposites)
- Results
- Discussion
- Conclusions & Suggestions
- References
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NOTE

- **Not more than two references to be cited from the internet-based article.**
- All papers reviewed must be cited in the text of the Report and appear under References. Attach copies of your cited references to your Report. (A sample research paper will be provided).
- ***Reports without page Numbers will not be graded.***

B. DESIGN PROJECT

Design **one of the following products** using a CAD software and write a Report

- a. Automobile front bumper;
- b. Football helmet;
- c. An industrial helmet;
- d. Telephone handset;
- e. Automobile door handle;
- f. Space shuttle control panel;
- g. F16 fighter canopy;
- h. Firefighter face-shield;
- i. Plastic Pump for an Automobile;
- j. Replacement Knee;
- k. Heart Valve;
- l. A plastic Gear for Watches.

Helpful Hint:

1. With the aid of the attached table, determine the factors that are of primary, secondary, or minor importance to be considered in selecting a polymer for the product. The Product will be fabricated by Injection Molding. In order to assign the required weights to the material ranking, a literature survey must be carried out. This will involve utilization of materials databases, such as ‘GE Select’ database, MOLDFLOW database or DuPont’s materials database. These sources of materials data are available on the Internet. Further information can be obtained by contacting the commercial resin suppliers of your particular resin. Further technical information can be obtained from texts and references, such as Modern Plastics Encyclopedia and Plastics Handbook, journals, such as Polymer Engineering Science, Journal of Applied Polymer Science, and so on, and conference proceedings, such as SPE ANTEC, SPI structural Foam Conferences, etc.

Design Project (Including Oral Presentation) 30%

The following tasks are to be completed in the design project assignment. Students will work in groups of 2.

1. Project Details

With the aid of CAD and CAE software you must carry out the following tasks:

- a) CAD design one of the parts listed.
- b) Generate an FE mesh using MOLDFLOW
- c) Mold cavity flow analysis using MOLDFLOW for the following:
 - i) Filling and post-filling, and examine
 - ii) weld line locations
 - iii) air trap locations
 - iv) skin orientation
 - v) part shrinkage
 - vi) part warpage
- d) Optimize your product design with respect to I) gate location and II) part geometry.

2. Guidelines for Project Report Writing (30%)

Please, use word processor and ORGANIZE your REPORT in the following format.

- A) Title Page: (Must have the following: Course and Section, Name of Product, Author's Name, Group Partners, Instructor's Name, Date Submitted)
- B) Table of Contents
- C) Abstract (of not more than 100 words)
- D) Introduction: The following Titles must appear in subsections under Section D.
 - (i) Project Objectives
 - (ii) Description of Product functions
 - (iii) Table of Part Lists
- E) Design Process
 - CAD design including drafts and full dimensions
 - Material selection: Resin manufacture contacts, literature review, manufacturer's manual etc.
- F) Evaluation of design (or computer model) for its moldability, using MOLDFLOW.
- G) Optimization of product design as outlined in section 1 above.
- H) Conclusions and recommendations
- I) Appendix

List of Factors to be Considered in Designing a Plastic Product

Mechanical	Type and magnitude of normal service stresses Loading pattern and time under load Fatigue resistance Allowable deflections
Thermal	Overloads and abuse; Impact resistance Normal range of operating temperatures Maximum and minimum service temperatures
Environmental	Solvent and vapor attack Reactions with acids, alkalis, water, etc. Water absorption effects Ultraviolet light exposure and weathering; oxidation Erosion by sand, rain, etc. Attack by fungi, bacteria, or insects
Electrical	Resistivity Dielectric loss Antistatic properties Tracking resistance
Hazards	Flammability Toxicity of additives or degradation products
Appearance	Transparency Surface finish Color matching and color retention Paintability
General	Tolerances and dimensional stability Weight factors Space limitations Expected service life Acceptance codes and specifications Leaching of additives Permeability to vapors and gases Weather resistance
Manufacturing	Choice of process Method of assembly Finishing and decoration Quality control and inspection
Economics	Material costs Cost of capital plant: molds and processing machines Number of molding/units required Operating costs of component, including maintenance and fuel consumption