FAMU–FSU College of Engineering
Department of Chemical and Biomedical Engineering

Transport Phenomena Laboratory

EXPERIMENT 004 WILDCARD!
SHEAR GENIUS

**" If I have ever made any valuable discoveries,
it has been owing more to patient attention, than to any other talent."
--Sir Issac Newton**

Background

Viscosity is how engineers measure the resistance of fluids to shear stress.

In most problem-solving exercises conducted in the sophomore and junior level Chemical Engineering curriculum, most fluids are assumed to behave as Newtonian fluids, meaning viscous stresses at every point are linearly proportional to the local stain rate. This assumption simplifies mathematical modeling of fluid flows, conveniently. In the Transport Phenomena Laboratory, students use Cannon-Fenske Viscometers to measure the viscosity of Newtonian fluids and apply the momentum transport models for Newtonian fluids. However, Non-Newtonian fluids are very common in industrial and biological processes. In this experiment, students will use another method for measuring viscosity: Rheometry.

In this assignment, students will use a Brookfield DV3TLV/ DV3THA rheometer to characterize the rheology of four unknown fluids. Using this data, students will construct a plot of shear stress versus shearing strain rate for all fluids, and use regression to fit a power law model for each unknown fluid. Students will examine and interpret the observed fluid behaviors. What constraints and challenges arise in designing equipment to process the unknown fluids?

Thus, student teams will have an opportunity to learn about Non-Newtonian Fluid Rheology, to design and conduct their own experiment in order to gather data, to formulate a mathematical model for the system, and to present their results and conclusions.

Academic Honor Policy Provision for Wildcard Experiments

The team will work independently on this experiment. **Teams may not communicate with anyone, other than the instructor and the TA overseeing the equipment operation, on this assignment.**

If the team is stuck on some aspect of this experiment, then consult *only* with the instructor or designated TA. If a team has a question on the applicability of the academic honor policy to this assignment, then consult with the instructor.

Students providing or receiving any information from anyone other than the instructor will receive a failing grade for the course and may be subject to additional penalties such as probation suspension, and dismissal from the student's university.

Learning Objectives

By the end of this assignment, the student will be able to:

- Design and conduct an experiment in a team environment to characterize the Rheology of four unknown fluids.
- Analyze and interpret the data to empirically fit the unknown fluids to a Power Law model, and construct a plot of shear stress versus shearing strain rate for all fluids.
- Communicate the results of an experiment on the rheological characterization of unknown fluid samples in an oral presentation to chemical engineers.

Experimental Objectives

Collect experimentally the shear stress (τ) vs. the velocity gradient (aka. rate of shearing strain) (dv_x/dy) needed to calculate the viscosity of the fluid. In the design of this experiment, students must consider the design of the Rheometer and the repeatability of their data.

Tip: Research Non-Newtonian Fluids and Rheometers prior to meeting with the TA to conduct the experimental trials.

Prepare graphs of shear stress (τ) vs. the velocity gradient (aka. rate of shearing strain) (dv_x/dy). Consolidate the data onto a single, neatly formatted plot. From these plots, determine whether each fluid exhibits Newtonian or Non-Newtonian Rheology. If the rheology is Non-Newtonian, can you classify the type of fluid behavior?

Using an appropriate regression technique, fit a Power Law Fluid Model to the data for each fluid. From the power law parameters, determine whether each fluid exhibits Newtonian or Non-Newtonian Rheology. If the rheology is Non-Newtonian, can you classify the type of fluid behavior?

Experimental Method
Students will conduct three repetitions of the experiment in their previously assigned teams outside of class. For this assignment, students will formulate their own methodology.

Students will utilize the Brookfield DV3TLV/ DV3THA located in room A-216. Students should coordinate with Ms. Roneisha Blakeney, who will oversee operation of the rheometer. For scheduling, use this doodle poll: https://doodle.com/poll/8agg4xmm9zkku9g7

Document the procedure in sufficient detail that another person can reproduce your results.

Students will also construct a data table to record the results from their measurements. Organize the table with columns neatly labeled.

Students may NOT use any other tools, equipment, or other materials from our Unit Operations Laboratory. The lab engineer will issue each team a kit that includes samples of the four unknown fluids. If more of any fluid is required, immediately notify the lab engineer. All waste from these fluids can be safely discarded down the drain. Return fluid containers—clean—to the lab engineer during the reconnoitering period on the day of your Oral Report.

Analysis
The team must present a Power Law Model for the four unknown fluids. The model will employ traditional regression techniques presented in undergraduate textbooks. Students will also exploit contemporary computational methods such as Excel or JMP.

Students must be able to explain the physics behind the experimental results and connect the results to the mathematical description.

Students must conduct a literature search of the library for journal, books and articles, many of which are available in digital format through the library website, to provide pertinent background information. Upon postulating the identity of the fluids, students should attempt to obtain literature values for the Power Law Parameters. Validate your model using your experimental results.

Hint: Food Engineering Text books can be found in the Dirac library catalog.

Oral Report
Refer to the lab manual for guidelines on oral technical reports.
The location of the presentation will be Room A113. The Lab Schedule lists the presentation date.

WILDCARD EXPERIMENT

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Evaluation Worksheet

Student Names _____ Team No. ___

Criterion	Value	Score
Ability to Design Experiments Did the team apply pertinent technical concepts and literature? Was there a fundamental model (hypothesis) for the experiment? Was there a strategic plan for the experiment trials?	3	
Ability to Conduct Experiments Was the operating procedure reliable and well executed? Did the team neatly record the data on a well-designed raw data sheet? Was there a schematic diagram of the apparatus?	2½	
Ability to Analyze and Interpret Data Did the team satisfactorily analyze the data to determine the results? Did the team evaluate the reliability of the results, and consider inconsistencies? Was there a comparison of experimental results with predictions? Were there practical recommendations?	3	
Ability to Communicate Did the team satisfactorily explain the pertinent technical concepts and terms? Did the team and handout explain the purpose and importance of the experiment? Did the team and handout explain the design, execution, and analysis of the experiment? Was the text of the handout free from grammatical and spelling errors?	2½	
Special Bonuses/Penalties (Explain) Were there exceptional features of the experiment that were insightful? (1-3 points bonus) Were there exceptional features of the presentation or handout that stimulated the audience? (1 point bonus) Were there gross errors or omissions in the content? (assignment grade "0") Other? Explain.		
Total	11	

Answer the following questions on the reverse side of this page:
What did you particularly like about this presentation? Was there some information new to you?
What would you have done differently if you had been the speaker?

Evaluator _____ Date _____