

Viscoelastic Materials

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 Date Created: August 8 2007
 Subject: Advanced Placement Physics (Calculus)
 Level: Juniors and Seniors
 Standards: Standard 1: Analysis, Inquiry, Design
Schedule: About 2 weeks

Objectives:

To understand the stress and strain relationships for an elastic solid, viscous (Newtonian) fluid, and a viscoelastic fluid.

Students will:

- Able to calculate stress and phase angle for an elastic solid subject to sinusoidal strain.
- Able to calculate stress and phase angle for a Newtonian fluid subject to sinusoidal strain
- Able to calculate stress and phase angle for a Maxwell fluid subject to sinusoidal strain
- Able to make predict conditions under which a Maxwell fluid can behave as an elastic solid, a Newtonian fluid

Vocabulary:

Elastic
 Young's Modulus
 Angular frequency
 Period
 Phase Angle
 Newtonian Fluid
 Viscosity
 Viscoelastic Fluid

Materials:

For Each Pair:
 Rubber Band
 Ruler
 Water
 Laptop with IDL software
 Demonstration:
 Glycerin solution
 Aluminum dilaurate in decalin

Safety:

Perfectly safe

Science Content for the Teacher:

Solution of first order differential equations
Knowledge of computer programming

Preparation:

Preparation of glycerin solution and Aluminum dilaurate in decalin.



Classroom Procedure:

Elastic Solid

Engage (Time: 5 min) Teacher will explain stress/strain relationships.

Explore (Time: 5 min) Students will stretch a rubber band and record their observations.

Explain (Time: 5 min) Students will explain their observations to the teacher.

Expand (Time: 30 min) Teacher will ask students to calculate stress for a sinusoidal strain. Teacher will ask students to write a computer program that calculates and plots stress. Use the computer program to calculate phase angle.

Newtonian Fluid

Engage (Time: 5 min) Teacher will explain stress/strain relationships.

Explore (Time: 5 min) Students will allow a drop of water to flow down a ruler.

Explain (Time: 5 min) Students will explain their observations to the teacher.

Expand (Time: 30 min) Teacher will ask students to calculate stress for a sinusoidal strain. Teacher will ask students to write a computer program that calculates and plots stress. Use the computer program to calculate phase angle.

Viscoelastic Fluid

Engage (Time: 10 min) Teacher will explain stress/strain relationships.

Explore (Time: 5 min) Students will look at teacher demonstration.

Explain (Time: 5 min) Students will explain the demonstration to the teacher.

Expand (Time: 30 min) Teacher will ask students to calculate stress for a sinusoidal strain. Teacher will ask students to write a computer program that calculates and plots stress. Use the computer program to calculate phase angle. Predict conditions under which a viscoelastic fluid can behave as an elastic solid, a Newtonian fluid.



Assessment:

The following rubric can be used to assess students during each part of the activity. The term “expectations” here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

- 1= exceeds expectations
- 2= meets expectations consistently
- 3= meets expectations occasionally
- 4= not meeting expectations

	Engage	Explore	Explain	Expand/Synthesis
1				
2				
3				
4				

Extension Activities:

Supplemental Information:

Safety:

Acknowledgments:

