Research Experience for Teachers Program

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Summer 2005

COOPERATIVE LEARNING ON OBSERVATION OF A UNIQUE MATERIAL PROPERTY

Subject: General Science

Grade Level: 9th ~ 12th

Time Allocation: Forty minutes

Aim: How to find out the Young's modulus through a simple experimental set up?

<u>Performance Objectives</u>
Utilizing the skills of teamwork, students work cooperatively to find out the factors of Young's modulus for two kinds of material through a simple experimental set up. After completing this class activity, students should be able to

1. understand the basic components and techniques of cooperative learning;
2. collect experimental data accurately and display data appropriately on graphs;
3. calculate and analyze the corresponding Young's modulus for the give materials.

<u>Components for Cooperative Learning</u>

1. Team size: five students (for a 30-students class).
2. Assignment to team: If there are thirty students in this lab class, teacher will assign a number to each student starting from 1 to 6. Next, all the "one"s will make up a team, all the "two"s will make up another team, all the "three"s will make up the third team, and so forth. Teacher will also ensure that the students are equally distributed among the teams depending on their talents.
3. Roles in each team:
   Messenger ---- reading the class instructions to direct this activity;
   Handler ---- to pick up and return all class activity materials for his/ her team;
   Operator ---- following the given procedure to carry out the experimental trials;
   Recorder ---- to record the observation results and to calculate the related data.
   Task master ---- keeping the group on the task by watching the time and is responsible for communicating with class teacher.

4. Positive interdependence: This class activity should be done cooperatively. Thus, every team member must be assigned a role to make a positive contribution for the completion of the class activity. Each team should fill in the data sheet, graph paper, and calculation results for the given materials on this activity; its team members should agree with the team observations and should be able to explain the final results.
5. Individual accountability: While doing this activity, each team member is expected to write down the common observations for the experiment. Furthermore, every student must be able to explain the method of experimental set up for the class activity. Teacher may call individuals to come to the board and to present their results.
6. Expected behaviors and monitoring: Teacher will expect to see all team members participating in the class activity and performing his/her role. Every student should know how to fill in the data sheet, to draw the graphs, and to calculate the final results for the class activity. During the class, teacher will circulate the room to monitor the progress of teamwork and to guide students with helpful hinds whenever it is necessary.
7. Criteria for success and closing: Teams will earn three points of credit for this class activity if they could successfully conduct teamwork, correctly graph the stiffness and accurately calculate the Young's modulus for the given materials. Finally, teacher will distribute the evaluation sheet to have students assess their cooperative behavior and comment on each team performance. Moreover, teacher could ask students to express their opinions on this activity, for instance, how to improve their performance in the teamwork? what are the suggestions for the better outcome on cooperative learning?

<u>Background Introduction</u>

1. Pedagogical approach

This lesson plan is designed to enrich and enhance students' learning interest in science class. It could be easily adapted into regular course curriculum at the beginning of the term, or at the end of the term, or anytime between. Through this class activity, students could have a chance to practice their teamwork spirit and academic skills. In order to encourage students to learn science knowledge from their daily living environment and physical setting, this lesson plan simplifies the concept of Young's modulus into a practical experimental set up, which could be fully carried out in a general science class from grades 9 to 12.

2. Basic knowledge

Everything on the Earth is pulled by the gravitational force, which is reflected as the weight of the object. When extra weights are applied on an object, the shape of the object will change to cope with the extra force. Materials respond to the applied force variously due to the difference on stiffness (a material property), for example, soft materials are easily bent because of their low stiffness. Thus, stiffness is a measure of the amount of applied force to bend the material. As to the same material, the geometrical structure also contributes to its resistance to the applied force. Specifically, in material science, Young's modulus is used to indicate the material property of stiffness.

<u>Supplies for Class Activity</u>

1. One set for entire class
   - Triple-beam balance
   - Masking tape
   - Strings
   - 6 copies of Role Assignment Form
   - 30 copies of Student Worksheet I
   - 30 copies of Student Worksheet II
   - 30 copies of Student Worksheet III
2. Six sets of each following items:
   - Two pencils
   - Wood meter stick
   - Metal meter stick
   - 250 mL graduated cylinder
   - Half-gallon size plastic container

Figure: Experimental set up

Class Activity Procedure

1. Form six teamwork groups, and fill out Role Assignment Forms.
2. Separate two pieces of same-height furniture (such as desks or lab stools) about 40-cm distance apart.
3. Use masking tape to fix a pencil at the surface edge of each furniture (as shown on the above figure).
4. Measure the distance between two pencils and record this data on the Worksheet III for further calculation.
5. Place a sample material (either the wood meter stick or metal meter stick) on the top of two pencils.
6. Hold the second meter stick straight up in the back of the sample material and record its height from floor as the zero displacement.
7. Measure the mass of plastic container with string on the triple-beam balance which will be the initial weight.
8. Hang the plastic container in the center of sample material, record its initial displacement that corresponds to the initial weight.
9. Measure 200 mL tap water with graduated cylinder, and slowly pour water into the plastic container (without any water spilling).
10. Record accurately the corresponding displacement under the loading force (mass of water plus mass of container) on the Worksheet I (Data Table).
11. Repeat Step 9 and 10 until filling 1800 mL of water into the plastic container, and complete all information on Worksheet I.
12. Switch to another meter stick as a new sample material, and repeat the above Step 5 through Step 11.
13. Draw a graph to display the relationships of "loading force vs. displacement" for two materials on the provided grid paper (Worksheet II).
14. Measure the width and thickness of both meter sticks, and record the data on the Worksheet III, then apply the given equation to complete the calculation for Young's modulus.

Theoretical Data of Young's Modulus for Some Materials

Type of Material	Unit in GPa (10^9 N/ m^2)	Converted Unit in kg/mm^2
Steel	195	1.99×10^4
Copper	120	1.22×10^4
Aluminum	70	7.14×10^3
Pine wood	11	1.12×10^3
Nylon plastic	2.8	2.86×10^2

Reference on Science Standards

This lesson plan aligns with following Science Teaching Standards on the ***National Science Education Standards***:

Standard A ---- Plan an inquiry–based science program.

- Select science content and adapt and design a curriculum to meet the interests, knowledge, understanding, abilities, and experiences of students.
- Select teaching and assessment strategies that support the development of student understanding and nature a community of science learners.

Standard B ---- Guide and facilitate learning.

- Focus and support inquiries while interacting with students.
- Encourage and model the skills of scientific inquiry, curiosity and openness to new ideas and skepticism that characterize science.

Standard C ---- Engage in ongoing assessment of teaching and student learning.

- Analyze assessment data to guide teaching.
- Guide students in self-assessment.

Standard D ---- Design and manage learning environments that provide students with the time, space, and resources needed for learning science.

- Create a setting for student work that is flexible and supportive of science inquiry.
- Identify and use resources outside the school.

Standard E ---- Develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

- Display and demand respect for diverse ideas, skills, and experiences of students.
- Model and emphasize the skills, attitude, and values of scientific inquiry.

Standard F ---- Participate in the ongoing planning and development of the school science program.

- Plan and develop the school science program.
- Participate in decisions concerning the allocation of time and other resources to the science program.

Bibliography

1. Gere, James M., ***Mechanics of Materials***
   Belmont, CA: Brooks/Cole-Thomas Learning, 2004
2. Cohen, G., ***Designing Groupwork: Strategies for the Heterogeneous Classroom***
   New York, NY: Teachers College Press 1994
3. National Science Teachers Association, ***National Science Education Standards***
   Washington, DC: National Academies Press, 2003
4. ***Dissemination of It for the Promotion of Materials Science ---- Beam Stiffness***
   www.doitpoms.ac.uk/tlplib/BD1/printall.php
5. ***Learning Together and Alone (the Cooperative Learning Center)***
   www.clcrc.com

Appendix A

Role Assignment Form

Group Number _______________ Date ___________

Today's class activity will be carried out through the method of cooperative learning; randomly pick up a role from the following list and it will be your contribution to the teamwork.

Messenger ---- reading the class instructions to direct this activity.

Handler ---- to pick up and return all class activity supplies for your team.

Operator ---- following the given procedure to carry out the experimental trials.

Recorder ---- to record observation results and related data during the experiment.

Task master ---- keeping the group on the task by watching the time and is responsible to communicate with class teacher.

Seat # in lab class	Print your name	Role in the team

Note: After the Role Assignment Form is completed, handler will submit this form to class teacher and pick up activity supplies for your team, and then your group can start the experiment.

Appendix B: Student Worksheet I

Data Table for Two Materials

Name ___________________________ Date _____________

Since the density of water is 1 g/mL, the mass of 200-mL water will be weighted as 200 grams.

Sample I (type of material): _____________________
Initial height of sample material: _____________________ (mm)
Initial weight of plastic container and string: ___________________ (g)

Water weight (g)		0	200	400	600	800
Loading force (g)						
Displacement (mm)						
Water weight (g)		1000	1200	1400	1600	1800
Loading force (g)						
Displacement (mm)						

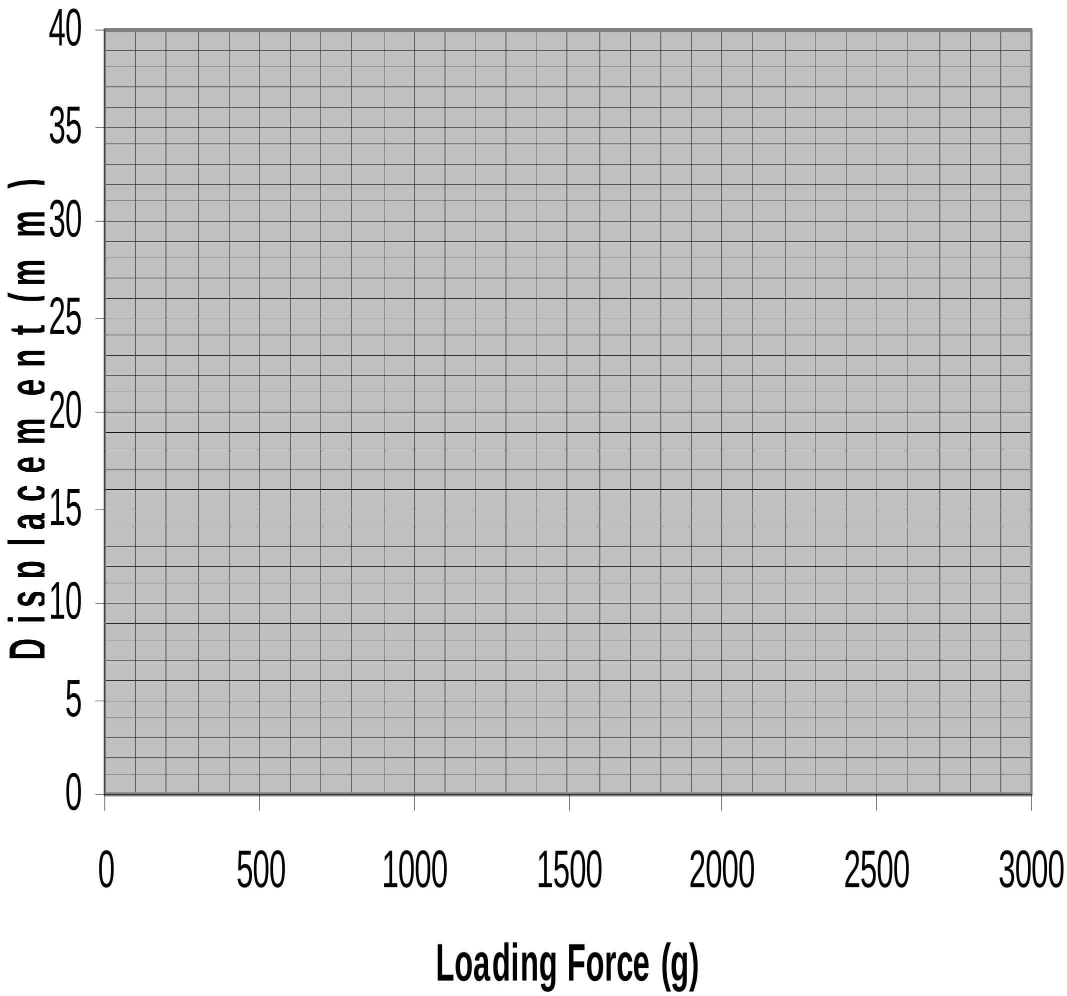
Sample II (type of material): _____________________
Initial height of sample material: _____________________ (mm)
Initial weight of plastic container and string: ___________________ (g)

Water weight (g)		0	200	400	600	800
Loading force (g)						
Displacement (mm)						
Water weight (g)		1000	1200	1400	1600	1800
Loading force (g)						
Displacement (mm)						

Appendix C: Student Worksheet II

Graph of "Loading Force vs. Displacement" for Two Materials

Name ____________________________ Date ______________



Appendix D: Student Worksheet III

Calculation on Young's Modulus for Two Materials

Name ________________________ Date ____________

Basic equation

$E = (f \times L^3) / (4 \times d \times W \times T^3) = \{L^3 / (4 \times W \times T^3)\} \times (f / d)$

E: Young's Modulus of the material with the unit of kg/mm^2
L: length between the two pencils in unit of millimeter
T: thickness of the sample in millimeter
W: width of the sample in millimeter
f: loading force in unit of kilogram
d: displacement of sample material in millimeter

Measurement and calculation on sample I
Type of material ____________________, W = __________ (mm)
L = __________ (mm), L^3 = __________ (mm^3)
T = __________ (mm), T^3 = __________ (mm^3)
(hint: copy loading forces (f) and displacements (d) from Worksheet I)

f (kg)										
d(mm)										
E										

Average of E for sample material I: __________ (kg/mm^3)

Measurement and calculation on sample II
Type of material ____________________, W = __________ (mm)
L = __________ (mm), L^3 = __________ (mm^3)
T = __________ (mm), T^3 = __________ (mm^3)
(hint: copy loading forces (f) and displacements (d) from Worksheet I)

f (kg)										
d(mm)										
E										

Average of E for sample material II: __________ (kg/mm^3)