

Research Experiences for Teachers (RET) – 2012
LESSON PLAN TEMPLATE

Topic: Friction.

STANDARD(S) & INDICATOR(S):

5.1.12.B.1 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.12. A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

OBJECTIVE(S): Student will be able to;

- Determine the forces involved when objects slide past one another with and without acceleration and the kinetic and static frictional coefficients of the surfaces and materials in relative motion.
- Determine the angles of repose for surfaces covered with powder (granular-like material) and cereal-like materials.

MATERIALS:

- Wooden blocks with the friction surfaces coated or covered with different materials.
- Calibrated (range) spring scales. Use the lowest spring scale to give the best reading whenever possible.
- Weights and balance corresponding to the spring scales being used.
- Appropriately mounted frictionless pulley and attachments for inclined surface measurements.
- Assorted powder-like/cereals-like materials representative of the materials used to coat the friction surfaces.
- Plain sheets of paper covered/coated with the friction materials under investigation.
- Ruler/meter stick, camera, protractor.
- Plains sheets of Manila paper and adhesive materials.
- Digital camera.

BACKGROUND INFORMATION:

When surfaces that appear smooth to the naked eye and those not so smooth (rough) move relative to one another, the nature of the frictional forces that come into play will be dependent on the nature of surfaces in contact and magnitude of the forces causing relative motion between those surfaces. The type of resulting friction is either kinetic or static. The same holds for powders and powder like materials that are generally common place in the pharmaceutical industry during the pre-processing, processing and during the whole process of manufacturing operations.

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An attempt is being made here to give the students an idea of how friction forces (macro) impact the handling processes by investigating the values and nature of the type(s) of friction coefficients involved.

CLASSROOM ACTIVITY DESCRIPTION (LABORATORY/EXERCISES/PROBLEMS) including detailed procedures:

Lesson Day 1.

On this day students will be introduced to the materials (powders/cereals-like materials) that will be used to cover or coat the contact surfaces of the wooden blocks. The students will investigate the sizes of the broken or milled cereals or powders that may be appropriate to cover the contact surfaces. They will then investigate the various ways of coating or impregnating the contact surfaces. After they have concluded on the most appropriate way of doing so they will then proceed to impregnate or coat the surfaces with their choices of materials. The wooden blocks so coated will then be left to dry up or stabilize in case the materials have been impregnated onto the surfaces using a proper agent/adhesive material.

Day 2.

Static friction:

The students will carry out the static friction tests by appropriately loading the wooden blocks placed on horizontal surfaces with different weights.

Students will place weights on the wooden blocks in suitable increasing amounts while gently pulling on the spring scale. (Ensure that the spring scale is properly calibrated to zero prior to the start of the experiment).

Students will record the corresponding spring scale reading and the weight (weight of masses plus that of the wooden block).

Students will continue doing so until they determine the maximum force required to just get the wooden block to move.

Students will create tables and record these weights and the necessary maximum force. They will do this three times and record the average value of the spring scale reading and its corresponding weight.

Kinetic friction:

In order to determine the kinetic friction value for each set of weights, the students will repeat the first part of the experiment but now they will measure the spring force (friction force) as they slowly drag the wooden blocks along at constant speed.

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Students will repeat this three times for each specific weight and determine the average value of the spring scale reading. They will then record this value and the corresponding weight.

Day 3.

Angle of Repose.

In order to determine this angle, students will first pour the materials onto plain sheet of paper placed on a horizontal table top. They will then determine the maximum angle formed between the sloping sides of the cone formed on the table top and the horizontal using the meter stick and ruler/protractor.

They will repeat this angle measurement by taking a photo of the arrangement with the camera. This must be done at as near a vertical position as possible to avoid any slanting of the angle measurement. Suitable runs could be done earlier and the accuracy of the photographic method ascertained.

Students will continue to pour different materials and take meter/ruler/protractor measurements and photographs of the angle arrangements.

Students will repeat the experiments with sheets of paper on which materials with different roughness will have been coated or covered on the sheets of paper. This is to ensure that there is a comparison with plain paper and roughened paper surface.

SAMPLE QUESTIONS TO ELICIT CLASS DISCUSSION:

- What kind of world would it be without friction and how would this impact the laws that we use to approximate forces and the resulting motion?
- In what ways do the types of surfaces of everyday objects that we handle have a bearing on the quality of life around us and safety?
- In what ways and how does friction affect how we make or manufacture products? Is there any cost to friction?
- What possible reason could there be for differences between forces required to initiate motion of an object and sustain its motion on a horizontal surface?

HOMEWORK ACTIVITY/EXERCISES/PROBLEMS:

Analysis of the data/results.

1. Students will determine the coefficient of friction for each set of weight/spring scale reading during the static friction experiment and then plot a graph of friction force against weight. The coefficient of friction is the ratio of the spring scale reading divided by the total weight of the masses and the wooden block.
2. Students will determine the coefficient of kinetic friction for each set of spring scale reading against the total weight. This is the ratio of the spring force reading divided by the total weight during the constant speed.

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3. Students will determine the coefficient of static friction for the various combinations of materials and paper surface types. The coefficient of static friction is given by the tangent of the angle between the cone slanting side and the horizontal plane.

PARAMETERS TO EVALUATE STUDENT WORK PRODUCTS:

1. Lab report detailing,
 - Sketches/diagrams of experimental set-up for all three sets of set-ups. Objective, theory, procedure, free-body diagrams of the forces
 - Tables of experimental data,
 - Equations and sample calculations showing method of determining the coefficients of friction in each case,
 - Accuracy of graphical plots depicting lines of static friction coefficient and kinetic friction coefficient.
 - Precautions to ensure accuracy of results as much as possible.
 - Discussions in their reports and comparisons of static and kinetic friction values for the various materials and surfaces.

REFERENCES:

1. Foundations of Physics. – Tom Hsu, PhD.

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