

2017 AP[®] PHYSICS 1 FREE-RESPONSE QUESTIONS

2. (12 points, suggested time 25 minutes)

A student wants to determine the coefficient of static friction between a long, flat wood board and a small wood block.

- (a) Describe an experiment for determining the coefficient of static friction between the wood board and the wood block. Assume equipment usually found in a school physics laboratory is available.
- Draw a diagram of the experimental setup of the board and block. In your diagram, indicate each quantity that would be measured and draw or state what equipment would be used to measure each quantity.
 - Describe the overall procedure to be used, including any steps necessary to reduce experimental uncertainty. Give enough detail so that another student could replicate the experiment.
- (b) Derive an equation for the coefficient of static friction in terms of quantities measured in the procedure from part (a).

A physics class consisting of six lab groups wants to test the hypothesis that the coefficient of static friction between the board and the block equals the coefficient of kinetic friction between the board and the block. Each group determines the coefficients of kinetic and static friction between the board and the block. The groups' results are shown below, with the class averages indicated in the bottom row.

Lab Group Number	Coefficient of Kinetic Friction	Coefficient of Static Friction
1	0.45	0.54
2	0.46	0.52
3	0.42	0.56
4	0.43	0.55
5	0.74	0.23
6	0.44	0.54
Average	0.49	0.49

- (c) Based on these data, what conclusion should the students make about the hypothesis that the coefficients of static and kinetic friction are equal?

_____ The static and kinetic coefficients are equal.

_____ The static and kinetic coefficients are not equal.

Briefly justify your reasoning.

- (d) A metal disk is glued to the top of the wood block. The mass of the block-disk system is twice the mass of the original block. Does the coefficient of static friction between the bottom of the block and the board increase, decrease, or remain the same when the disk is added to the block?

_____ Increase _____ Decrease _____ Remain the same

Briefly state your reasoning.

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Question 2

12 points total

**Distribution
of points**

(a)

i. 3 points

For drawing a diagram of an experimental setup to measure the coefficient of friction that is feasible in a school physics lab

1 point

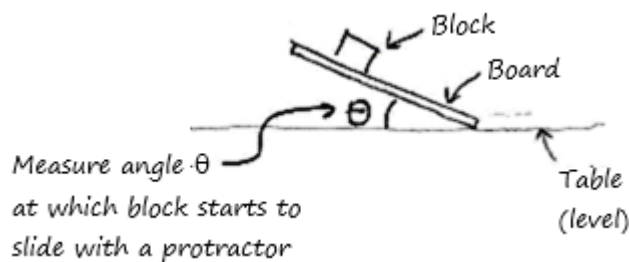
For indicating the measurements necessary for calculating the coefficient of friction

1 point

For indicating equipment necessary for measuring the quantities required to calculate the coefficient of friction

1 point

Example:



ii. 3 points

For a description that is consistent with the diagram in part (a)(i), in enough detail that another student could replicate the experiment

1 point

For a description that is a conceptually valid method to find quantities that would allow a calculation of a friction coefficient

1 point

For including a valid method for reducing experimental error

1 point

Example:

With the block at rest on the board, slowly lift one end of board until the block just begins to slide. Measure the angle between board and table and repeat several times with block at different locations on the board (with multiple trials at each location).

(b) 3 points

Note: In order to earn full credit for part (b), all terms (variables) must be indicated in the diagram and/or procedure of part (a).

For using Newton's second law (or reasoning in terms of zero net force) in one dimension, parallel to the board's surface, either explicitly or implicitly

1 point

For using Newton's second law (or reasoning in terms of zero net force) in one dimension, perpendicular to the board's surface, either explicitly or implicitly

1 point

Note: Replacing the normal force with mg is "implicit" use of Newton's second law in the perpendicular direction for a horizontal surface. For a tilted surface, the appropriate trigonometric term should be included.

For a correct derived expression of the coefficient of static friction in terms of quantities indicated in part (a)

1 point

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Question 2 (continued)

**Distribution
of points**

(c) 2 points

Correct answer: “The static and kinetic coefficients are not equal.”

Reasoning cannot earn credit if the incorrect selection is made.

For identifying group 5’s results as outliers, or indicating the presence of an outlier

1 point

For a conclusion that coefficients are not the same, justified by either removing the outlier or noting the coefficients are different for each group

1 point

(d) 1 point

For a valid argument that indicates the coefficient of static friction is a property of the two surfaces, and is consistent with the selected answer

1 point

Example 1: Selects “Remain the same”

Referring to the equation in part (b), coefficient does not depend on mass.

Example 2: Selects “Remain the same”

The coefficient depends on the nature of the surfaces involved, not the masses or normal force of the objects involved.

Example 3: Selects “Decrease”

The increased normal force will cause smoothing of the surfaces, decreasing the coefficient of friction.

Example 4: Selects “Increase”

The increased normal force will cause the surfaces to become gouged, increasing the coefficient of friction.