

Comparing Friction on Three Surfaces — Teacher copy

Answers and suggested responses

Research Question

How does surface material affect the steady horizontal pulling force needed to slide the same block slowly at constant speed in a straight line?

1. Identify the Independent Variable (IV) – the factor you change:

Answer: Independent Variable (IV): The surface material (bare wood, sandpaper, wax paper).

3. List three Controlled Variables – factors you must keep constant to ensure a fair test:

Answer: Controlled Variables: 1. Block mass and contact face used. 2. Pull angle (must be horizontal). 3. Approximate speed and path length.

2. Identify the Dependent Variable (DV) – the factor you measure:

Answer: Dependent Variable (DV): The steady horizontal pulling force measured in Newtons (N).

4. State your prediction: Which surface will require the most force to slide the block, and which will require the least? Explain your reasoning using what you know about surface textures and friction.

Answer: Accept a prediction supported by a reason, even if the results later differ. Example: I predict that the block will need a larger pull on sandpaper than on wax paper, based on how these surfaces feel. This is a prediction to test, not a rule that rougher surfaces always have more friction. The pair of materials and their surface conditions both matter.

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Equipment & Safety Setup

- Equipment: Low wooden block with secure attachment, suitable spring scale (range selected by teacher), three secured surfaces (bare wood, sandpaper, wax paper), tape, ruler.
- Teacher Check: Ensure the teacher checks your scale range and attachments before pulling.
- Zeroing the Scale: Zero your spring scale horizontally without any load before starting.
- Safety & Technique: Keep the block flat on the table, pull horizontally away from the table edge, pull with no jerks, and never overload the scale.

Procedure

1. Secure bare wood, sandpaper and wax paper with tape. 2. Use the same block face and mass for every trial. 3. Attach the zeroed spring scale horizontally. 4. Pull slowly at approximately constant speed in a straight line. 5. Read the scale during steady sliding; ignore the starting peak. 6. Record the pulling force in newtons (N). Repeat jerky trials. 7. Take three readings per surface. Add them and divide by three to find the mean. Round to the precision of your scale readings.

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Friction Investigation Data Table

Surface Material	Trial 1 (N)	Trial 2 (N)	Trial 3 (N)	Mean Force (N)
Bare Wood				
Sandpaper				
Wax Paper				

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5. Draw a labelled force diagram of the block sliding to the right on a level table with a horizontal pull at a constant speed in a straight line. Show and label the four forces acting on the block: pull (right), friction (left), normal force (up), and gravity/weight (down). Ensure the relative sizes of your arrows show whether the forces are balanced or unbalanced.



Force Diagram of a Sliding Block

Answer: Force Diagram: Block on a level table with a horizontal pull at a constant speed in a straight line. Arrows: Pull (right) and Friction (left) must be equal in length (opposing forces are balanced); Normal force (up) and Gravity/Weight (down) must be equal in length.

6. Explain why a steady scale reading alone does not prove that the forces acting on the block are balanced. What else must you observe about the block's motion?

Answer: A steady scale reading alone does not prove that the forces acting on the block are balanced. To prove balance, you must also observe that the block is moving at a constant speed in a straight line (no acceleration or change in direction).

7. Conclusion 1: Based on your experimental data, how does the surface material affect the steady horizontal pulling force (kinetic friction) needed to slide the block? Use specific numbers from your data table to support your answer.

Answer: Accept conclusions supported by the student's own measurements. Illustrative data only: bare wood 1.0, 1.1, 1.0 N; sandpaper 1.8, 1.9, 1.8 N; wax paper 0.6, 0.7, 0.6 N. Add each set of three readings and divide by three. Means rounded to 0.1 N are 1.0 N, 1.8 N and 0.6 N. In this example, sandpaper requires the greatest steady pull and wax paper the least. Actual results may differ. These measurements compare friction for this block and these surfaces; they do not identify the microscopic cause.

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8. Conclusion 2: Based on your evidence, compare the friction on the three surfaces. Why is it incorrect to say that visual roughness is the only factor that determines friction?

Answer: Accept comparisons supported by the student's measurements. Friction depends on the pair of contacting materials, the force pressing them together and their surface conditions. Visual roughness alone does not predict the result. In the simple dry-friction model used here, changing apparent contact area at the same normal force does not by itself change friction appreciably. This investigation compares forces; it does not establish the microscopic cause of a difference.

9. Exit Question 1: A block is resting on a table. You pull it with a force of 0.5 N, but it does not move. Then, you pull it with 1.0 N and it slides at a constant speed. Which statement is true?

- ☐ **A** At rest, the static friction force was 0.5 N, balancing your pull. In motion, the kinetic friction force is 1.0 N, balancing your pull.
- ☐ **B** At rest, there was no friction acting on the block because it was not moving.
- ☐ **C** In motion, the pulling force must be greater than the friction force to keep it moving.
- ☐ **D** Static friction is always smaller than kinetic friction.

Answer: A. At rest, the static friction force was 0.5 N, balancing your pull. In motion, the kinetic friction force is 1.0 N, balancing your pull.

10. Exit Question 2: A ball is thrown straight up into the air. At the very top of its flight, when its speed is momentarily zero, what forces act on it? (Neglect air resistance.)

- ☐ **A** No forces act on it because its speed is zero and it is momentarily at rest.
- ☐ **B** Only the downward force of gravity acts on it.
- ☐ **C** Both gravity pulling down and an upward throwing force act on it, balancing each other.
- ☐ **D** Only an upward force acts on it because it is still high in the air.

Answer: B. Only the downward force of gravity acts on it.