Ramp Force Test

Use measurements to test a force model for a stationary block.

PHY.2.8 "Design an experiment to determine the forces acting on a stationary object on an inclined plane. Test your conclusions."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the measurements used to infer forces, circle the two tests of the force model, and number the four forces acting on the block while it rests on the incline.

Why Does the Block Stay Put?

1. A block on a loading ramp can remain motionless even when gravity pulls it downhill. To find out why, measure its weight with a spring scale before placing it on the ramp. Measure the ramp angle, then use trigonometry to split weight into a part parallel to the ramp and a part perpendicular to it. The ramp pushes back with a normal force perpendicular to its surface. Attach the scale so it pulls the block uphill, parallel to the ramp. Static friction acts along the surface, opposing the direction the block would otherwise start to move.

2. For one trial, a 0.50 kg block weighs 4.90 N and rests on the ramp at 30 degrees. The downward component of its weight along the ramp is 2.45 N, while its component into the ramp is about 4.24 N. A spring scale attached parallel to the ramp reads 1.00 N as it pulls uphill. The block remains still. Because the ramp exerts no force along its surface except friction, the forces along the incline must balance. Friction points uphill if the block would otherwise tend to slide downhill.

3. An independent check begins with the same ramp laid flat. Pull the block horizontally with the spring scale and record the reading just before it slips. Suppose that reading is 2.00 N. On the level ramp, the normal force equals the block's weight, so the reading estimates maximum static friction there. For the same surfaces, maximum static friction scales approximately with normal force. Next, restore the 30-degree slope and reduce the uphill pull while watching for motion. Compare the pull needed to prevent slipping with the value predicted from the horizontal test.

2 ANSWER WITH EVIDENCE

Use the passage

1. Name the four forces on the stationary block in the inclined trial. State the direction of each force.

2. How large must static friction be to keep the block still when the scale reads 1.00 N? What is the normal force?

3. Use the level-ramp test to estimate maximum static friction at 30 degrees. Is it enough to hold the block when the scale reads 1.00 N?

4. Predict what will happen if the uphill pull is reduced to zero at 30 degrees. What observation would challenge the force model?

3 YOUR TURN

Your own words

Choose a new incline angle and an uphill scale pull for the same block. Describe what you would measure, predict the directions of all four forces, and explain how a horizontal threshold test and an inclined trial could test your prediction.

ANSWER KEY

Ramp Force Test

PART 1 · READ AND MARK

Underline the measurements used to infer forces, circle the two tests of the force model, and number the four forces acting on the block while it rests on the incline. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Name the four forces on the stationary block in the inclined trial. State the direction of each force.	**Weight points vertically down, the normal force points perpendicular outward from the ramp, the scale pulls uphill parallel to the ramp, and static friction points uphill.**
2	How large must static friction be to keep the block still when the scale reads 1.00 N? What is the normal force?	**Static friction is 2.45 N minus 1.00 N, or 1.45 N uphill. The normal force is about 4.24 N.**
3	Use the level-ramp test to estimate maximum static friction at 30 degrees. Is it enough to hold the block when the scale reads 1.00 N?	**The estimate is 2.00 N × (4.24 N ÷ 4.90 N), or about 1.73 N. Yes, it exceeds the required 1.45 N.**
4	Predict what will happen if the uphill pull is reduced to zero at 30 degrees. What observation would challenge the force model?	**The block should slide downhill because its 2.45 N downhill weight component exceeds the estimated 1.73 N maximum static friction. If it remains still, the model or its measurements need rechecking.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Set the ramp to 20 degrees and pull the block uphill with 0.50 N. Measure its weight, the angle, and the scale reading. Weight points vertically down, the normal force points outward from the ramp, and the pull and predicted friction point uphill. The downhill weight component is about 1.68 N, so friction must supply about 1.18 N. On the level ramp, pull horizontally and measure the threshold. A 2.00 N threshold predicts a maximum of about 1.88 N at 20 degrees. Then check whether the block stays still with the 0.50 N uphill pull. Sliding would challenge the prediction.

Accept reasonable rounding and any new angle and pull supported by a consistent force balance. A horizontal threshold reading estimates maximum static friction on the level ramp because the pull is horizontal and the normal force equals the block's weight.