When Props Slide

Draw forces and predict motion on a tilted platform.

PHY.2.9 "Draw diagrams of forces applied to an object and predict the angle of incline that will result in unbalanced forces acting on the object."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline where the passage tells you to point each force arrow, and circle the rule for deciding when an object slides.

The Tilting Stage

1. A stage crew tests whether a prop will stay on a tilting platform. A force diagram starts with a dot or box for the object. Draw weight, mg, straight down. Draw the normal force, N, perpendicular to the platform and away from it. Draw static friction, f_s, along the surface and uphill when the prop tends to slip downhill. The downhill part of weight is mg sin θ, while the part pushing into the surface is mg cos θ. These parts help you compare forces, but neither is an extra force arrow.

2. Static friction adjusts to match the downhill pull until it reaches its limit, $\mu_s N$. For an object at rest, N = mg cos θ, so the platform can hold it when mg sin θ ≤ $\mu_s$mg cos θ. Since mg cancels, compare tan θ with μ_s: the object first slides at a tested angle where tan θ > μ_s. At equality, it may still remain at rest at the limit. A waxed wooden sled has μ_s = 0.40. The crew tests the sled at 15°, 25°, and 35°, increasing the angle between trials.

3. Next, the crew places a rubber-bottomed case on the same platform. Its coefficient of static friction is μ_s = 0.75, and the crew tests 25°, 35°, and 40°. For both objects, use these approximate values: tan 15° = 0.27, tan 25° = 0.47, tan 35° = 0.70, tan 40° = 0.84, and tan 50° = 1.19. The coefficient describes the contact between an object and the platform, not the object's mass. When you make a force diagram at an angle that holds, show uphill static friction balancing the downhill part of weight, even though the weight arrow itself points vertically down.

2 ANSWER WITH EVIDENCE

Use the passage

1. At 15°, sketch a force diagram for the sled. Label each force and show its direction. Is the net force along the slope zero?

2. Which tested angle is the first at which the sled slides? Compare tan θ with μ_s.

3. At 35°, sketch a force diagram for the rubber-bottomed case. Label each force and state whether friction can balance the downhill pull.

4. Which tested angle is the first at which the rubber-bottomed case slides? Compare tan θ with μ_s.

3 YOUR TURN

Your own words

Invent a crate with a coefficient of static friction between 0.28 and 0.83 that differs from both props in the passage. Predict its first sliding angle from 15°, 25°, 35°, 40°, and 50°; draw its force diagram at 15° and write a comparison that supports your prediction.

When Props Slide

PART 1 · READ AND MARK

Underline where the passage tells you to point each force arrow, and circle the rule for deciding when an object slides. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	At 15°, sketch a force diagram for the sled. Label each force and show its direction. Is the net force along the slope zero?	**The diagram shows mg vertically down, N perpendicular outward, and f_s uphill. Yes. tan 15° ≈ 0.27 < 0.40, so static friction balances the downhill pull.**
2	Which tested angle is the first at which the sled slides? Compare tan θ with μ_s.	**25°. tan 15° ≈ 0.27 < 0.40, but tan 25° ≈ 0.47 > 0.40.**
3	At 35°, sketch a force diagram for the rubber-bottomed case. Label each force and state whether friction can balance the downhill pull.	**The diagram shows mg vertically down, N perpendicular outward, and f_s uphill. Friction can balance the downhill pull because tan 35° ≈ 0.70 < 0.75.**
4	Which tested angle is the first at which the rubber-bottomed case slides? Compare tan θ with μ_s.	**40°. tan 35° ≈ 0.70 < 0.75, but tan 40° ≈ 0.84 > 0.75.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

For $\mu_s = 0.55$, the diagram at 15° shows mg straight down, N perpendicular outward, and f_s uphill, balancing the downhill pull. The crate first slides at 35° because tan 25° ≈ 0.47 < 0.55, while tan 35° ≈ 0.70 > 0.55.

Accept diagrams with correctly directed force arrows even if arrow lengths are not to scale. For the open task, the chosen angle must be the first listed angle whose tangent exceeds the student's coefficient.