CRITICAL-ANGLE FRICTION

Using the onset of sliding to determine μ_s

Name: _____	Period: _____	Date: _____

INVESTIGATION QUESTION **What relationship connects the critical incline angle and the coefficient of static friction?**

TIME 30 minutes	SIMULATION BuildPhysics > Critical-angle friction	UNIT 2 Force & Translational Dynamics

Learning targets

- Locate the smallest incline angle that produces sustained sliding.
- Test whether the critical angle depends on block mass.
- Use the critical angle to determine a coefficient of static friction.

Model before you measure

At the threshold of motion, the downhill weight component equals maximum static friction.	$mg \sin\theta = \mu_s mg \cos\theta \quad \tan\theta = \mu_s$

Important: Use $g = 9.8\ m/s^2$. Near the threshold, change the ramp angle in increments of about 0.5° and reset before deciding whether motion is sustained.

Pre-lab prediction | 4 minutes

1. For $\mu_s = 0.50$, estimate the critical angle before testing.

2. Should doubling the block mass change the critical angle? Explain from the force equation.

3. What force changes as the ramp angle increases even though the block's weight stays constant?

PART A Test whether mass affects the critical angle

Setup | 3 minutes

- ☐ Load Critical-angle friction. Keep $\mu_s = 0.50$, $\mu_k = 0.35$, and friction enabled.
- ☐ Select the ramp and adjust its upper endpoint. Measure the angle in degrees.
- ☐ For each mass, find the largest angle with no sustained slide and the smallest angle with sustained sliding.
- ☐ Estimate the critical angle as the midpoint of those two measurements.

Sustained motion: A tiny settling motion does not count. The speed should continue increasing down the ramp after release.

Data table | 10 minutes

Mass (kg)	Last no-slide angle (deg)	First sliding angle (deg)	Estimated critical angle (deg)	tan θ
1.0				
2.0				
4.0				

Force diagrams | 3 minutes

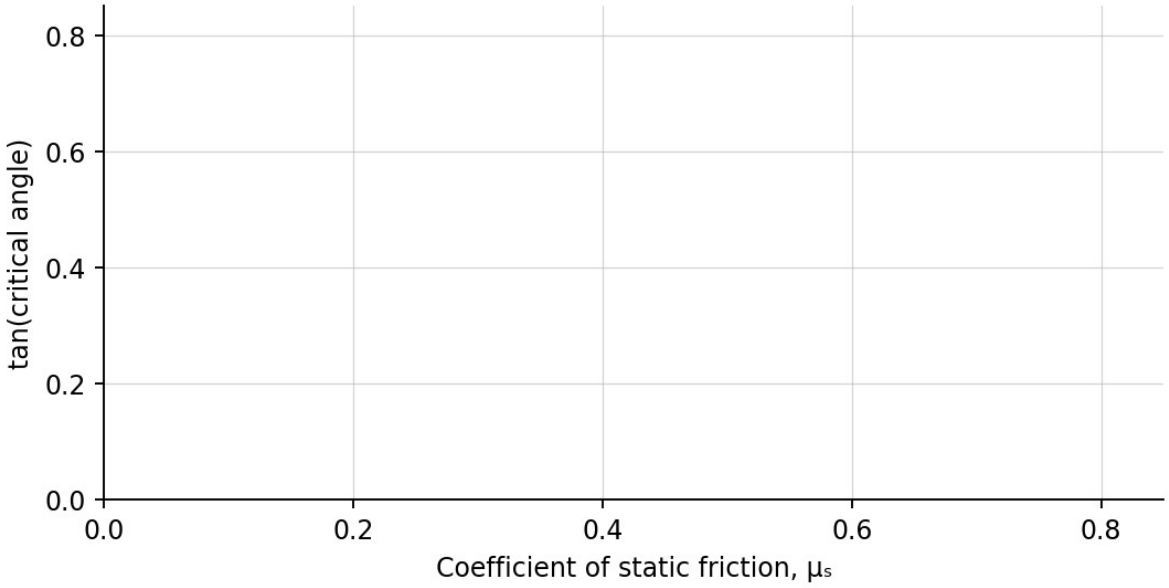
Just below critical angle	Just above critical angle
Draw and label F_N, mg, and static friction.	Draw and label F_N, mg, and kinetic friction.

PART B Change μ_s and test the model

Coefficient test | 7 minutes

Control: Keep mass at 2.0 kg. Change μ_s on both the block and ramp as needed, then locate the critical angle.

μ_s	Measured critical angle (deg)	tan θ
0.30		
0.50		
0.70		



4. Plot tan θ versus μ_s. Draw the expected relationship.

Analysis | 6 minutes

5. Did mass affect the critical angle? Use evidence from Part A.

6. How closely did tan θ match μ_s?

7. Why does mass cancel from the critical-angle relationship?

Claim-Evidence-Reasoning conclusion

Evaluate this statement: “A heavier block begins sliding at a smaller incline angle than a lighter block with the same surfaces.”

CLAIM	Accept, reject, or revise the statement.
EVIDENCE	Cite at least two measurements or graph features.
REASONING	Connect your evidence to the force model and Newton's laws.

Exit ticket

Predict the critical angle for $\mu_s = 0.60$. State the relationship you use.