FORCES DAY 11: SYNTHESIS

WARMUP **Day 9 Review**

A 2.0 kg cart on a frictionless table is tied to a 2.0 kg hanging mass over a pulley. Find the system's acceleration.

Physics in the Wild — Crash-Scene Detectives: Accident investigators measure skid marks, test the road's μ with a drag sled, compute the deceleration from μg, and run kinematics *backward* to find how fast the car was really going — testimony that stands up in court. That's a Day 4 + Day 5 + Unit 1 chain, which is exactly what today is: no new physics, just everything at once.

THE FOUR-STEP SEQUENCE

- **1. FBD** — every force, correct directions, nothing extra
- **2. Axes** — tilt them along the motion (inclines!), split angled forces into components
- **3. ΣF = ma per axis** — the perpendicular axis usually hands you F_N
- **4. Kinematics** — if the question wants distance, time, or speed, the a from step 3 feeds Unit 1

Every problem this unit — pushes, elevators, ramps, pulleys — comes down to these same four steps.

PUSH DOWN VS. PULL UP

WE DO Exercise 1: The Downward Push

A 10 kg crate is pushed with 50 N directed 37° *below* the horizontal, on a floor with $\mu_k = 0.20$. **(a)** Find F_N — the push's downward component adds to the load. **(b)** Find the friction force. **(c)** Find the acceleration.

YOU DO Exercise 2: The Upward Pull

The same 10 kg crate is instead pulled with 50 N at 37° *above* the horizontal (same $\mu_k = 0.20$). Repeat parts (a)–(c), then answer: why do movers pull their dollies rather than push down on them?

F_N moved — so friction moved. Same crate, same floor, same 50 N: pushing down gave more friction, pulling up gave less. Any time a force has a vertical component, recompute F_N before touching friction.

EVERYTHING AT ONCE

CHALLENGE **Exercise 3: Atwood Meets Friction**

A 4.0 kg cart sits on a table with $\mu_k = 0.25$, tied over an edge pulley to a 2.0 kg hanging mass. **(a)** Find the friction force on the cart. **(b)** Find the system's acceleration — driving force minus friction, over total mass. **(c)** Find the string tension from the hanger's FBD, then verify with the cart's FBD.

YOU DO **Exercise 4: Sanity Check the Setup**

Before computing anything in Exercise 3, you could have asked: "Does it move at all?" Compare the hanging weight to the cart's *maximum static friction* (take $\mu_s \approx 0.30$) and show the system does start moving.

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Find the Applied Force

An 8.0 kg crate accelerates at 2.5 m/s² across a floor with $\mu_k = 0.15$ under a horizontal push. Find the push.

P2 Connected, with Friction

Blocks of 3.0 kg and 2.0 kg are connected by a string on a floor with $\mu_k = 0.20$, the 3.0 kg block pulled forward with 30 N. Find the system's acceleration and the tension in the string.

P3 Find μ from the Motion

A 10 kg box pushed with a horizontal 40 N accelerates at 2.0 m/s². Find μ_k.

P4 Ramp + Kinematics

A block is released from rest on a 30° ramp with $\mu_k = 0.20$ and slides 3.0 m to the bottom. Find its acceleration (Day 9) and its speed at the bottom (Unit 1).