FORCES DAY 4: THIRD LAW & FRICTION

WARMUP **Day 3 Review**

A 5.0 kg cart experiences a net force of 15 N. Find its acceleration, showing the units dividing out to m/s².

Physics in the Wild — You Cannot Push Yourself Forward: When you walk, your foot pushes the Earth *backward* — and by Newton's Third Law, the Earth's friction pushes *you* forward. That's why you can't walk on wet ice: no friction, no third-law partner to carry you. Every locomotion on Earth — walking, driving, swimming, flying — is a third-law transaction.

NEWTON'S THIRD LAW

If A pushes B, then B pushes A — equal magnitude, opposite direction.

- The pair acts on **two different objects** — pair forces never appear on the same FBD
- Pair forces are the **same type** (friction ↔ friction, gravity ↔ gravity)
- Test for a pair: swap the words. "Earth pulls book down" ↔ "book pulls Earth up"

FRICTION

Sliding: $f_k = \mu_k F_N$

Fixed size once sliding starts.

Not sliding: $f_s \leq \mu_s F_N$

Matches the demand, up to its maximum.

μ has no units — it's a force divided by a force: N/N. And friction depends on F_N, which (Day 2!) is not always mg.

AP FREE-RESPONSE PRACTICE

FRQ Type — Qualitative/Quantitative Translation: paragraph answers are graded claim → evidence → reasoning. State your claim, cite the law, and connect them in complete sentences.

AP FRQ · QUALITATIVE/QUANTITATIVE

Truck Meets Car

A 3000 kg truck collides head-on with a 1000 kg car. During the collision, the truck exerts a 6000 N force on the car.

(a) A classmate says: "The truck obviously hits the car harder than the car hits the truck." In a short paragraph, evaluate this claim using Newton's Third Law.

(b) Compute each vehicle's acceleration during the collision. Carry units through both divisions.

(c) The car clearly suffers more in the crash. In one or two sentences, reconcile the equal forces from part (a) with the unequal outcomes, using your accelerations from part (b).

WORKING WITH FRICTION

WE DO Exercise 1: Kinetic Friction

A 5.0 kg box slides across a level floor with $\mu_k = 0.30$. Find the friction force: first F_N from the vertical equation, then $f_k = \mu_k F_N$.

YOU DO Exercise 2: Does It Slide?

A 10 kg crate rests on a floor with $\mu_s = 0.50$. You push horizontally with 40 N. **(a)** Find the maximum static friction available. **(b)** Does the crate slide? **(c)** What is the actual friction force on the crate right now?

YOU DO Exercise 3: μ from a Skid

A skidding car decelerates at 4.9 m/s² on a level road, with friction as the only horizontal force. Show that $\mu_k = a/g$ — write $\Sigma F = ma$ and watch the mass cancel — then compute it.

The most-missed Third Law question: the pair of "Earth pulls book down" is "book pulls *Earth* up" — NOT the table's normal force. Normal force and weight can be equal (book at rest), but they act on the same object and are different types — never a third-law pair.

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Kinetic Friction

An 8.0 kg sled slides on a level surface with $\mu_k = 0.25$. Find the friction force.

P2 Name the Pair

For each force, write its Newton's-Third-Law partner: **(a)** a bat pushes a ball forward; **(b)** Earth pulls a skydiver down; **(c)** a swimmer's hands push water backward.

P3 Slide or Stay?

A 4.0 kg toolbox rests on a bench with $\mu_s = 0.60$. You push it horizontally with 20 N. Does it move, and what friction force acts on it?

P4 μ from Motion Data

A hockey bag slides at 12 m/s and friction brings it to rest in 24 m. Find the deceleration from kinematics, then μ_k from Newton's Second Law.