A Teacher's Guide to Hidden Forces Misconceptions

Why students can solve F = ma problems and still not understand what a force is

For physics teachers and department leads

A field guide to five persistent forces misconceptions that survive conventional teaching and hide behind strong problem-solving performance. Includes an example diagnostic heatmap and details on how to run a free classroom pilot.

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Why Solving Problems Is Not the Same as Understanding Forces

A student scores 80% on a forces test. They can draw free-body diagrams for standard setups, apply F = ma to find an acceleration, and resolve forces on an incline. Their mark says they understand Newton's laws.

But ask them a different kind of question — one that tests the reasoning behind the diagram rather than the diagram itself — and the picture changes. Ask them whether a ball tossed straight up has a force on it at the very top of its arc. Ask them what the normal force equals when someone pushes down on a book resting on a table. Ask them to identify the Newton's third law partner of the weight of a book sitting on a surface.

What emerges is not a gap in effort or ability. It is something more persistent: a stable but incorrect mental model that produces correct answers on routine problems and wrong answers when the question requires genuine conceptual reasoning. The student does not know they hold it. The teacher cannot see it in a percentage score. And unless it is specifically surfaced, it survives instruction, revision, and even strong exam results.

Physics education researchers have documented this pattern extensively. Hestenes, Wells and Swackhamer's Force Concept Inventory revealed that students completing introductory physics courses often retained the same Aristotelian force beliefs they entered with — despite passing exams. Halloun and Hestenes showed that conventional instruction produced negligible shifts in students' underlying force concepts, even when procedural performance improved. Arons demonstrated that students who could correctly apply F = ma often could not explain what a net force actually means or why a stationary object on a table requires forces to be in balance. Across decades of research, the finding is consistent: students can pass forces tests while holding the same misconceptions they entered with.

The pattern is consistent: conventional assessment rewards procedural fluency — the ability to set up equations, label diagrams, and produce numerical answers — but is largely blind to conceptual coherence. A class can look competent on paper while carrying systematic misconceptions about what forces are, how they pair, and what Newton's laws actually say.

The diagnostic layer most physics departments are missing is not a harder problem set. It is a different kind of test — one designed to surface the specific misconception a student holds, not just whether their final answer is right or wrong.

Five Forces Misconceptions Worth Tracking

These are five persistent and instructionally important conceptual errors in Newtonian mechanics, documented across decades of published research. Each one survives conventional teaching and produces correct answers often enough to stay hidden.

Trap 1: The Impetus Belief (motion requires a sustaining force)

Ask students what forces act on a ball after it has left the hand. Many will still include a “force of the throw” or a continuing force in the direction of motion. This is the impetus belief: the idea that motion requires a sustaining cause. It is one of the most historically persistent misconceptions in mechanics and survives even explicit instruction on Newton's first law.

Ref: Hestenes, Wells & Swackhamer, 1992; Halloun & Hestenes, 1985

Trap 2: The “ma” Force (treating ma as a force on the diagram)

Students are taught that F = ma. Many then place “ma” on their free-body diagram as if it were an actual force acting on the object — alongside weight, normal force, and friction. They treat Newton's second law as a list of forces rather than a relationship between net force and acceleration. The result is a diagram with one too many arrows and a fundamental confusion about what the equation means.

Ref: Arons, 1997; Knight, 2004

Trap 3: The N = mg Reflex (normal force always equals weight)

Ask students for the normal force on a book sitting on a table while someone pushes down on it. Many will answer “mg” — ignoring the additional downward push entirely. They have memorised N = mg as a universal fact rather than understanding it as a special case that only holds when no other vertical forces are present and the surface is horizontal and non-accelerating. This error carries into incline problems as well, where students often default to N = mg instead of reasoning from the force balance perpendicular to the surface.

Ref: Arons, 1997

Trap 4: The Cancellation Trap (third-law pairs cancel each other out)

Students learn that Newton's third law says forces come in equal and opposite pairs. Many then conclude that these pairs must cancel — and cannot explain why anything accelerates at all. The error is a failure to recognise that third-law pairs act on different objects. The book pushes down on the table and the table pushes up on the book, but these forces do not cancel because they are not acting on the same object.

Ref: Hestenes, Wells & Swackhamer, 1992

Trap 5: The Ghost Force (forces from agents no longer in contact)

Ask students to draw a free-body diagram of a ball that was thrown upward, at a point after it has left the hand and is still rising. Many will include a “force of the hand” — an upward arrow representing the throw — even though the hand is no longer in contact with the ball. They are drawing a force from memory of the event rather than from analysis of what is currently touching the object. This ghost force error reveals a failure to apply the fundamental principle: only current interactions produce forces.

Ref: Hestenes, Wells & Swackhamer, 1992; Arons, 1997

Example Heatmap Using Simulated Data

Illustrative data (n = 22)

Simulated dataset shown to illustrate the heatmap output format and the kinds of misconception patterns a diagnostic can reveal. Informed by documented misconception patterns in physics education research. Not drawn from a classroom or pilot cohort.

Mean: 8.4/14 (60%) **Median:** 8/14 **Range:** 3–14

This heatmap shows results from Module 3 (Weight, Gravity & Normal Force), one of six available modules. Each module produces its own heatmap in the same output format.

Q#	Concept Tested	Overall	A (12–14)	B (9–11)	C (6–8)	D (0–5)	Cluster
Q01	Mass vs weight (Earth to Moon)	68%	100%	83%	57%	33%	M3-A
Q02	N3 partner of book's weight	50%	100%	67%	43%	17%	M3-D
Q03	Astronaut in orbit: gravity?	45%	80%	67%	29%	17%	M3-B
Q04	N when pushing down on book	41%	80%	50%	29%	17%	M3-C
Q05	N when rope pulls up on book	36%	80%	50%	14%	17%	M3-C
Q06	When does N equal mg?	55%	100%	67%	43%	17%	M3-C
Q07	What does a scale measure?	50%	100%	67%	29%	17%	M3-E
Q08	Scale: elevator accel down	59%	100%	83%	43%	17%	M3-E
Q09	Free fall: weight and N?	41%	80%	50%	29%	17%	M3-B
Q10	N3 pair: book on table	45%	80%	67%	29%	17%	M3-D
Q11	Scale always reads mg? (T/F)	55%	80%	83%	43%	17%	M3-E
Q12	Gravity zero in orbit? (T/F)	64%	100%	83%	57%	17%	M3-B
Q13	Push down → N > mg? (T/F)	36%	80%	50%	14%	17%	M3-C
Q14	N3 partner of N? (T/F)	41%	80%	50%	29%	17%	M3-D

% Correct: 0–20% 20–50% 50–70% 70–90% 90–100%

1 **Q05, Q13 — Band C/D: 14–17% correct.** The N = mg persistence is severe in lower bands. Students default to N = mg even when an additional force changes the situation.

2 **Q03, Q09 — Band B: 50–67%.** The weightlessness misconception is not confined to weaker students — it persists well into Band B.

3 **Q02, Q10, Q14 — Overall 41–50%.** Newton's third law pairing errors cut across all bands. Students confuse forces on the same object with action-reaction pairs.

Red cells mark the highest-leverage targets. Compare the Overall column against Band C/D to find misconceptions hiding behind class averages.

For classroom pilots, FundaFirst HS generates a class heatmap from your students' responses and delivers it within 48 hours of completion.

What Teachers Receive from a Classroom Pilot

Within 48 hours of your class completing the diagnostic, we deliver a complete misconception analysis to your inbox:

Class-level misconception heatmap. Performance by question and by student performance band, with each item tagged to a misconception cluster. Colour-coding helps show more clearly where understanding breaks down across the class. Each module you run produces its own heatmap.

One-page cohort summary. Which misconception clusters hit hardest, what they mean, how your class distributes across performance bands, and what the overall profile tells you about where your students are.

Band-level profiles. What each performance band means for your students — from "ready to extend" to "needs foundational rebuilding" — with specific guidance on what each group needs next.

Targeted remediation toolkit. Not generic revision advice. A set of materials — including worksheets with solutions, targeted exercises, and conceptual correction resources — mapped to the specific misconceptions your class triggered. Diagnosis and remediation in one package, so you do not need to build anything yourself.

Everything is teacher-readable, designed for immediate classroom use, and delivered as part of the free pilot. The pilot is provided at no charge and without obligation.

How to Run a Pilot

Step 1. Request a pilot. Visit fundafirsths.com or email admin@fundafirsths.com.

Step 2. We send the diagnostic link. You choose which module matches your current unit — or run more than one. You receive a diagnostic link and a short setup message you can paste directly to your students. No student accounts, no logins, no software installs needed.

Step 3. Students complete the diagnostic. Share the link with your class. Each module takes about 15 minutes and can be completed in class or as a short take-home task.

Step 4. You receive the full analysis. We generate your class heatmap, cohort summary, band profiles, and remediation toolkit for each module, and email everything to you — typically within 48 hours of class completion.

There is no charge for the classroom pilot. No payment information is collected. No subscription is created. No ongoing commitment.

The diagnostic covers core forces and Newton's laws content taught in IB Physics, AP Physics 1, A-Level/AS Mechanics, and GCSE/IGCSE Physics. Six modules are available: What Is a Force; Newton's First and Second Laws; Weight, Gravity and Normal Force; Free-Body Diagrams; Applying Newton's Laws in Context; and Newton's Third Law.

A 25-question Motion and Kinematics diagnostic is also available.

Request a classroom pilot

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