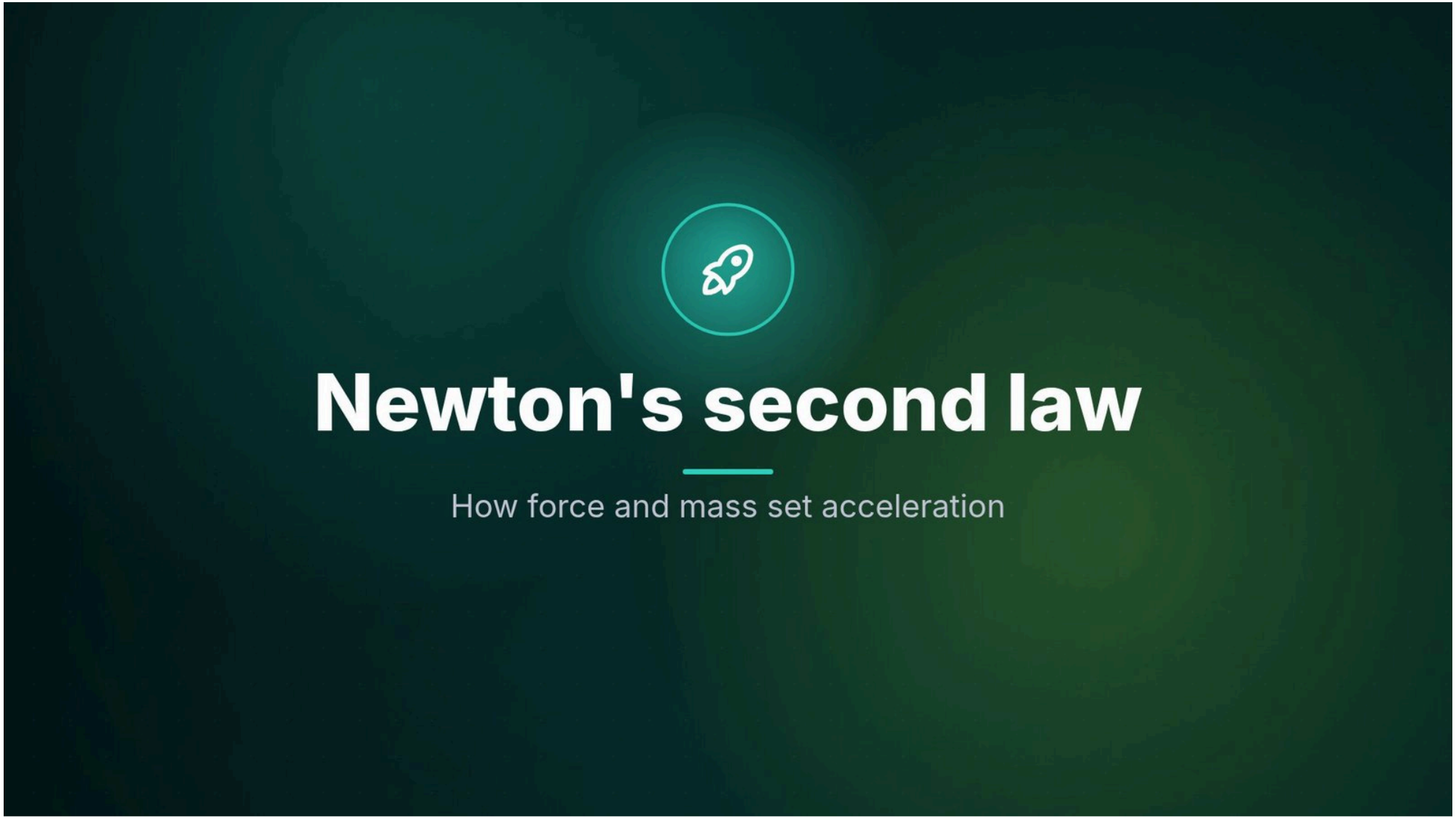
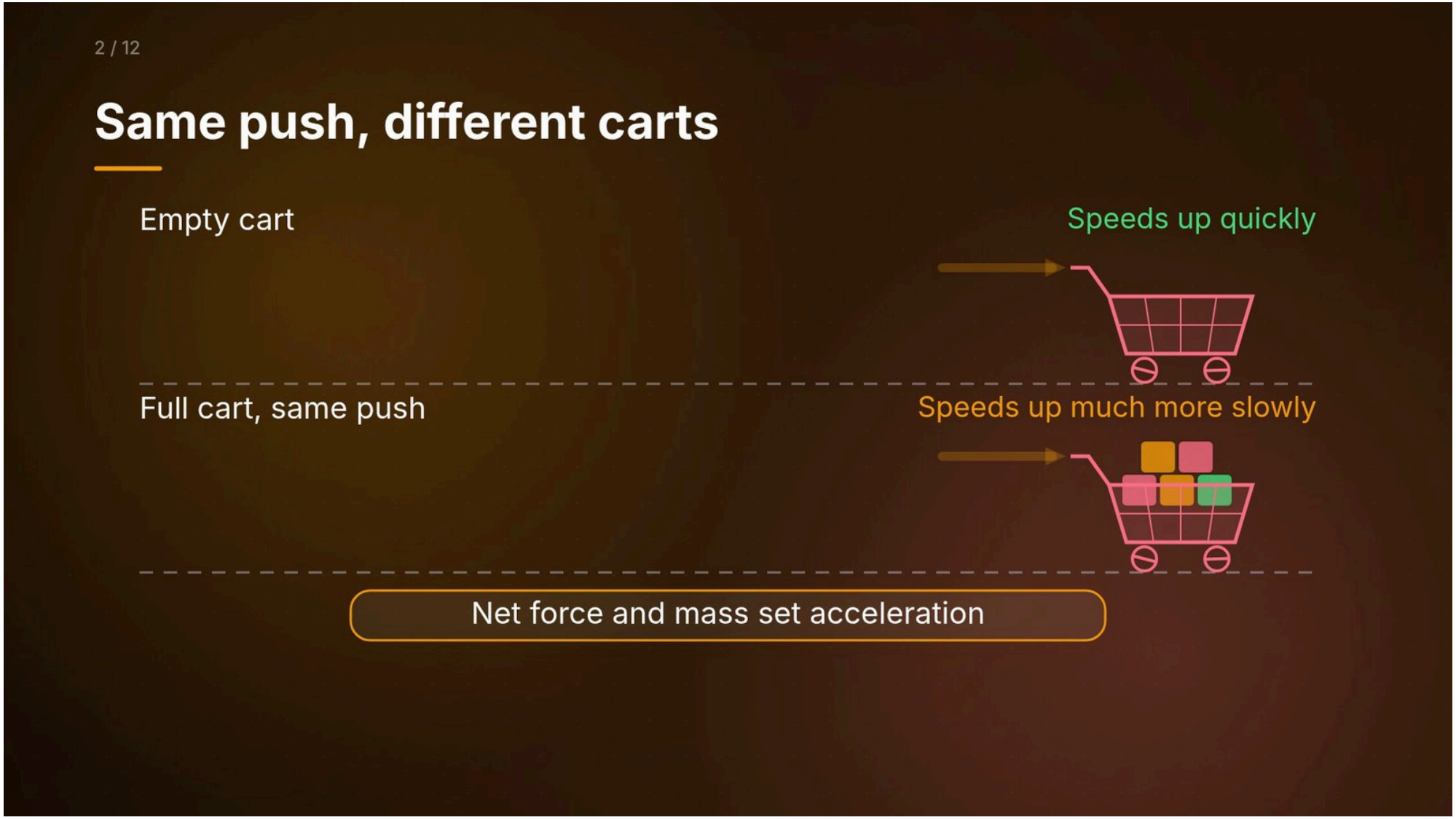


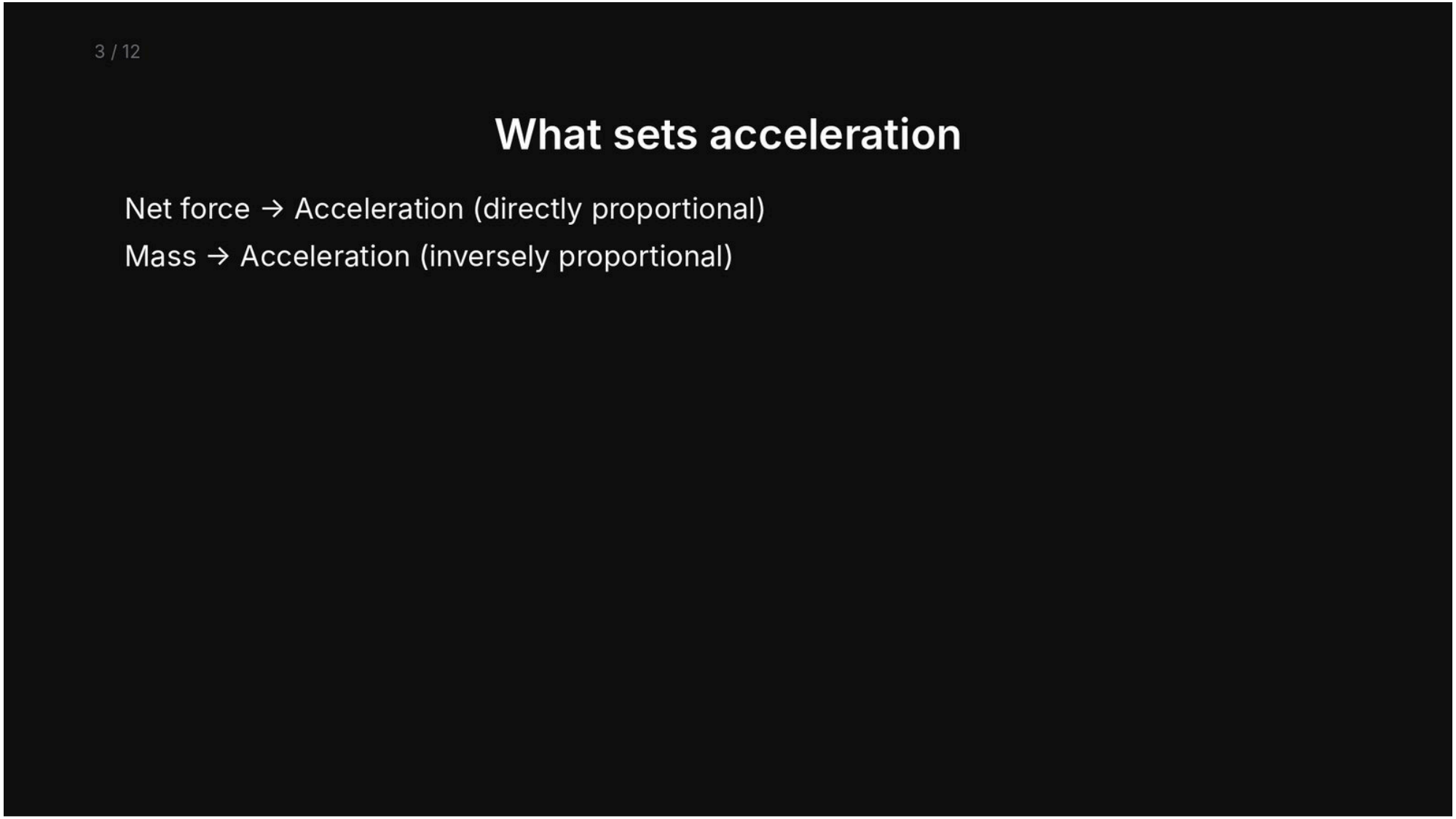
1 / 12 · Force, mass and acceleration

Why does a full shopping cart feel so much harder to get moving than an empty one? By the end of this video, you'll understand Newton's second law, how to use F equals m times a, and why heavy and light objects fall at the same rate.



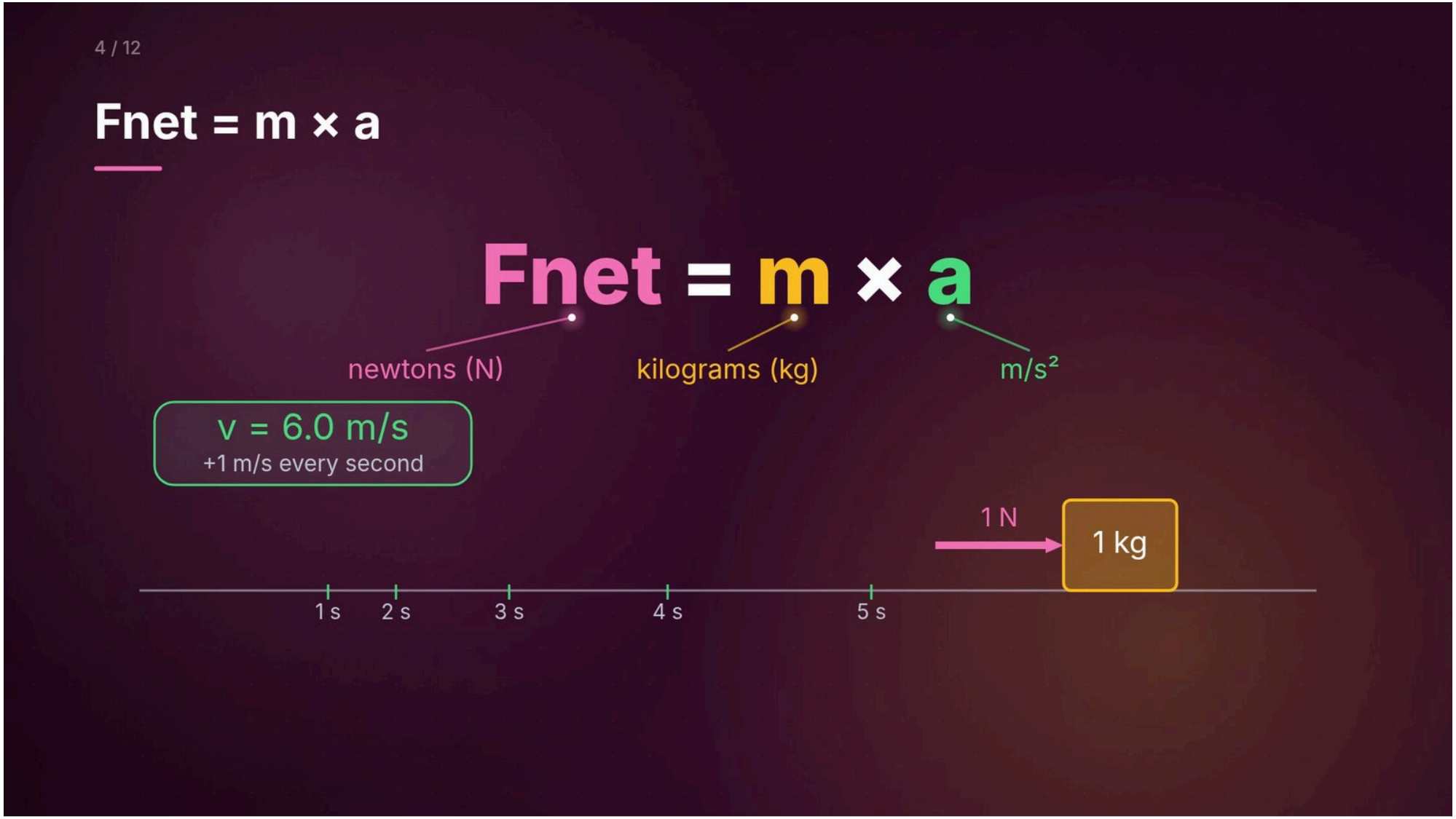
2 / 12 · The shopping cart puzzle

Push an empty shopping cart and it speeds up quickly. Push a full one just as hard, and it speeds up much more slowly. Newton's second law explains why: how quickly velocity changes depends on the net force and the object's mass.



3 / 12 · The law itself

Here's the law itself. Acceleration is directly proportional to the net force, so more force means more acceleration. It's inversely proportional to mass, so more mass means less acceleration. And the acceleration always points in the same direction as the net force.



4 / 12 · The equation and units

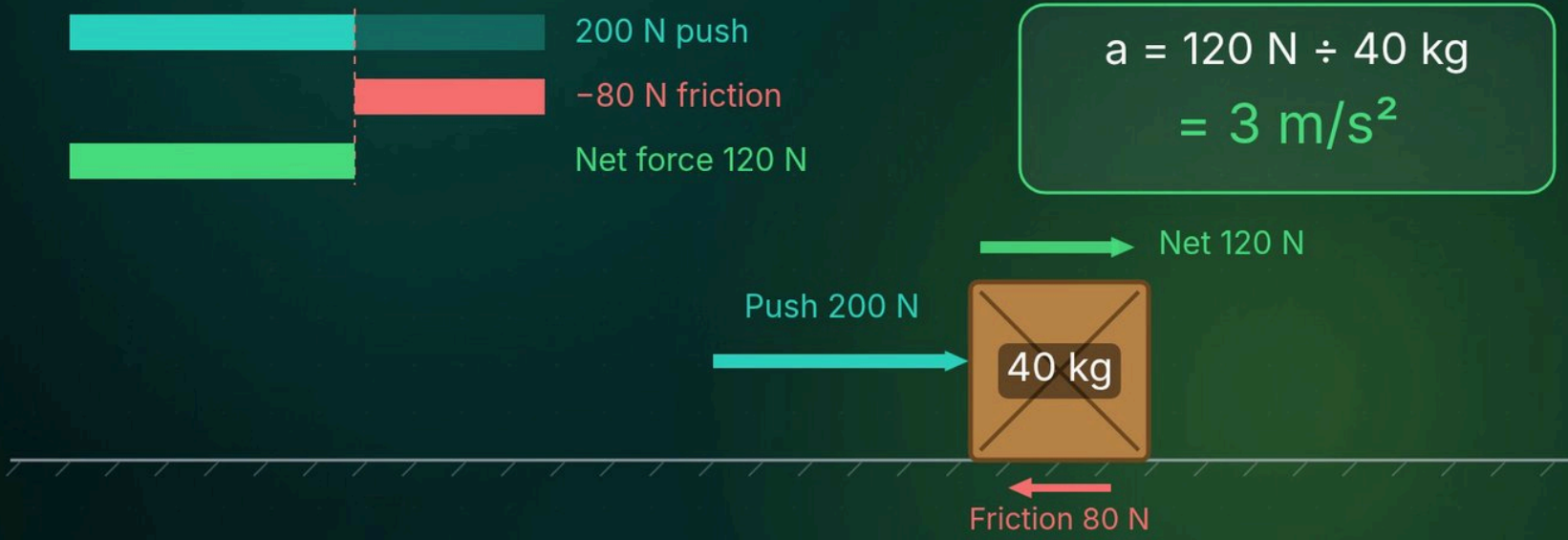
In symbols, F net equals m times a. F net is the total force in newtons; if several forces act, add them as vectors first. Mass is in kilograms, and acceleration is in metres per second squared. One newton is the net force that gives one kilogram an acceleration of one metre per second squared.



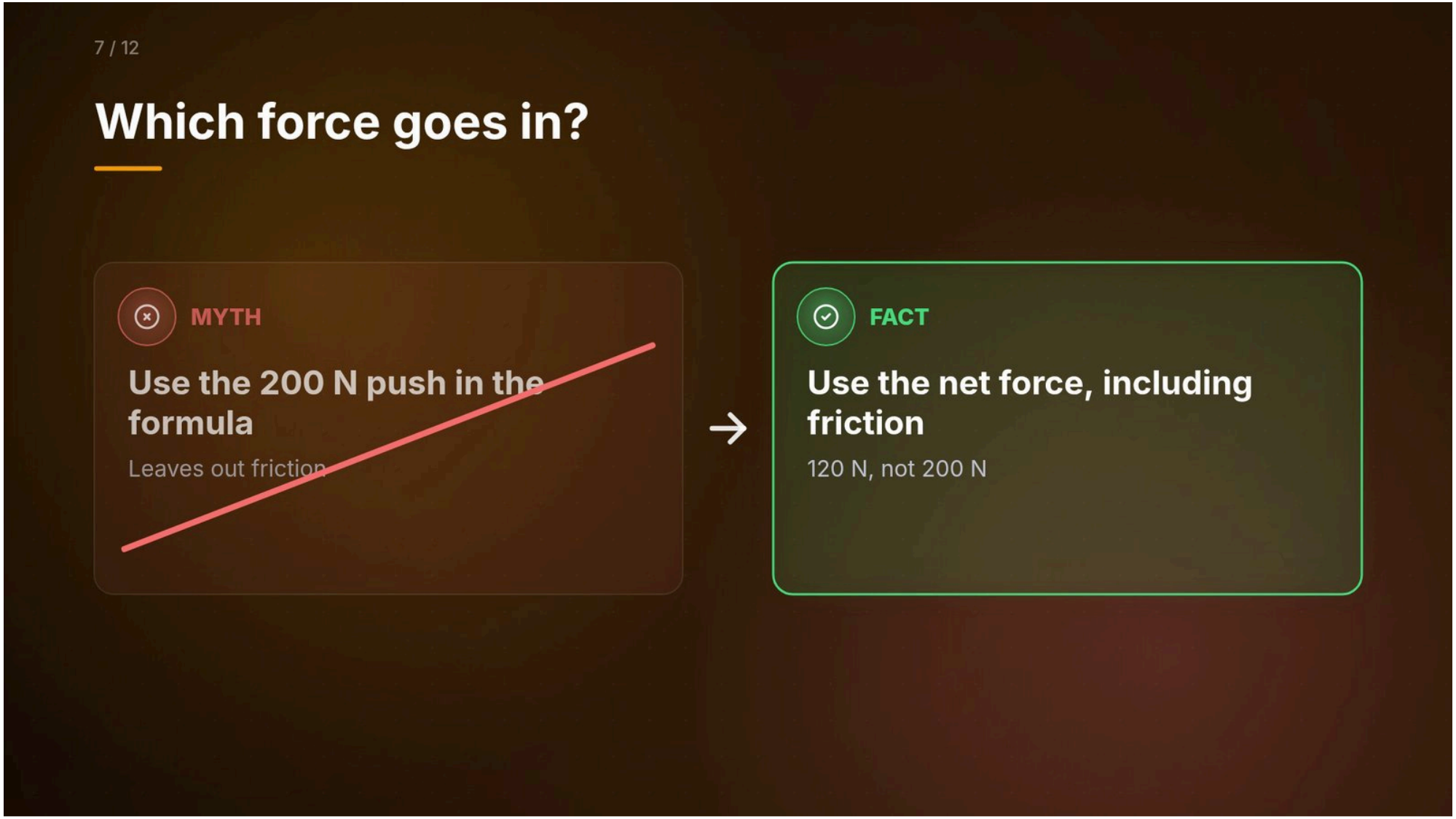
5 / 12 · Same force, different masses

Now keep the net force fixed at 60 newtons and change the mass. A 10 kilogram cart accelerates at 6 metres per second squared. Double the mass to 20 kilograms and the acceleration halves to 3. At 30 kilograms, it drops to just 2.

Finding the crate's acceleration

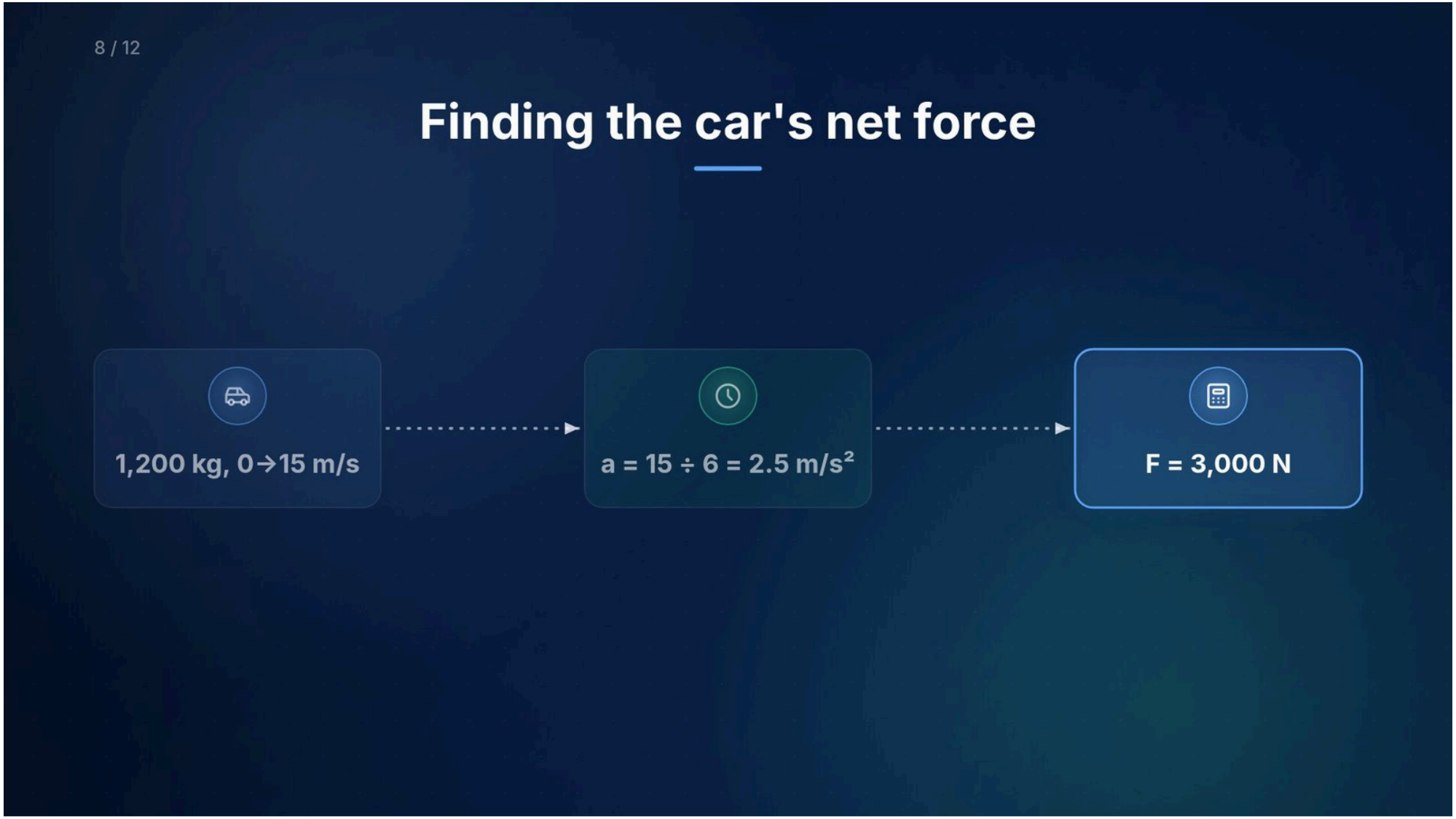


Try a real problem: a student pushes a 40 kilogram crate with 200 newtons, while friction pushes back with 80. First find the net force: 200 minus 80 is 120 newtons. Then divide by the mass: 120 over 40 gives 3 metres per second squared.



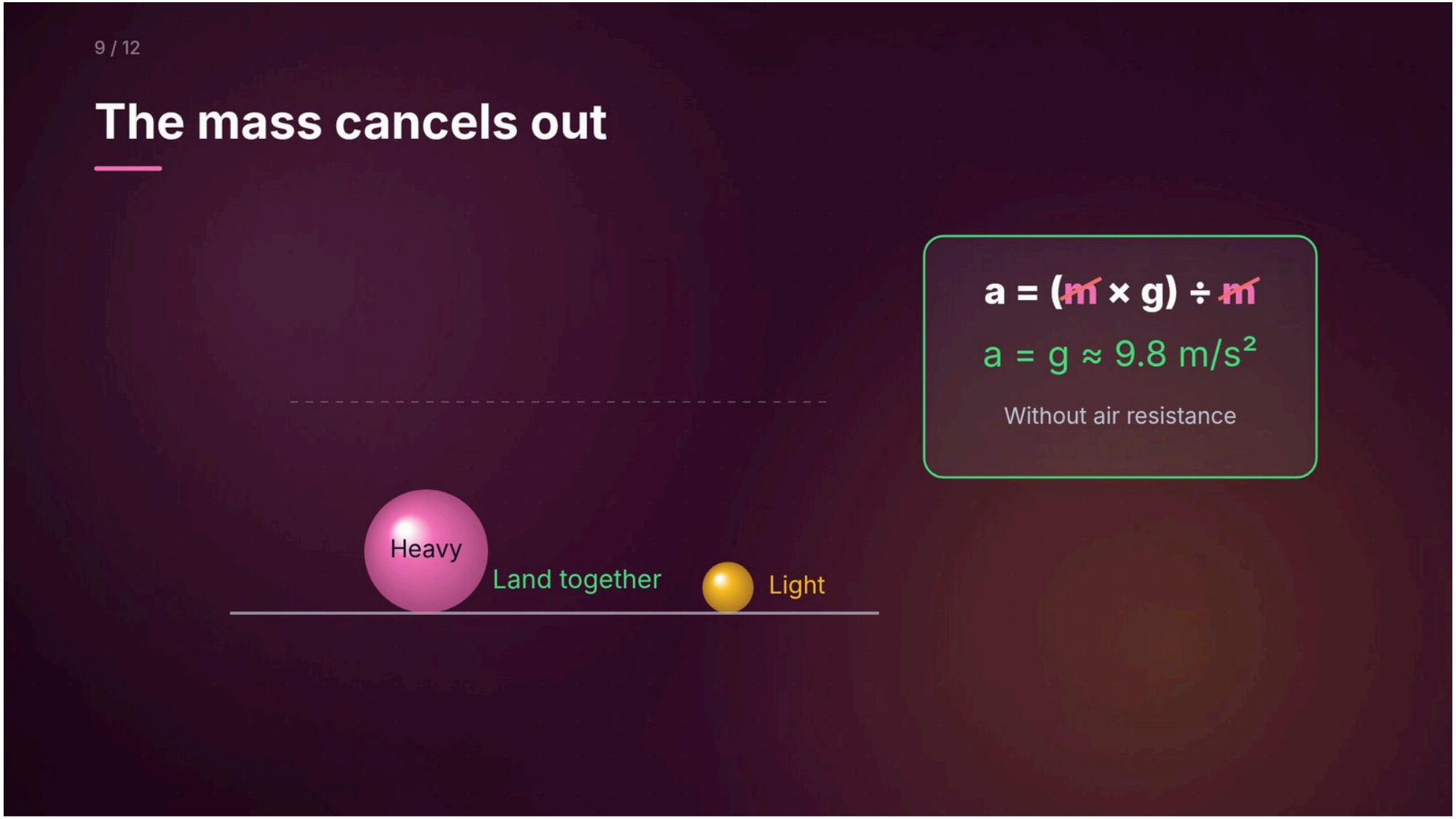
7 / 12 · The common mistake

The common mistake here is plugging the 200 newton push straight into the formula. That ignores friction, which is a force too. The law needs the net force, so always total up every force before you divide by mass.



8 / 12 · Worked example: the car

The law works in reverse too. A 1,200 kilogram car goes from rest to 15 metres per second in 6 seconds. Its acceleration is change in velocity over time: 15 divided by 6, or 2.5 metres per second squared. Multiply by the mass, and the net force is 3,000 newtons.



9 / 12 · Why everything falls together

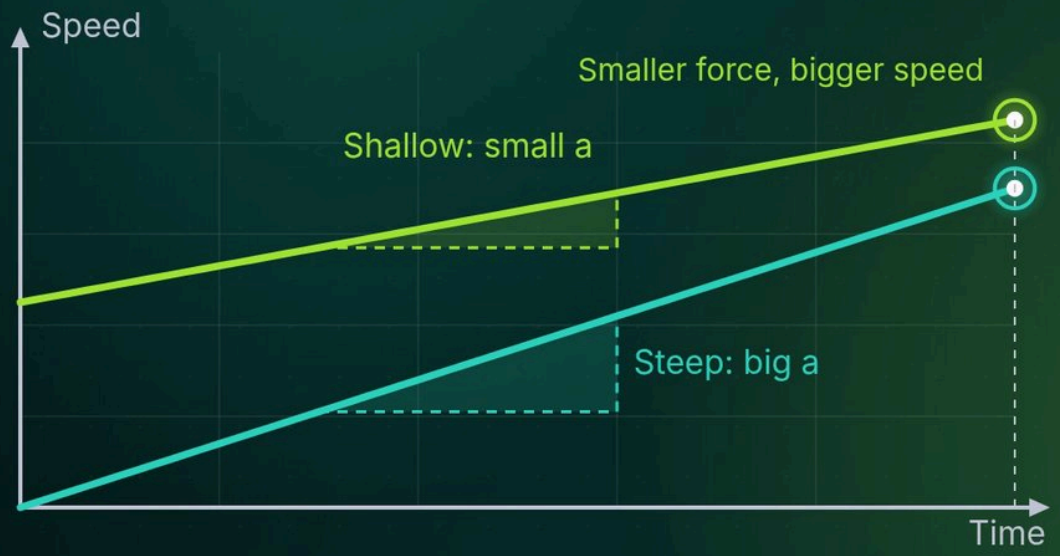
So why do heavy and light objects fall at the same rate? Gravity pulls harder on a heavier object, with a force of m times g. But that object also has more mass to speed up. Divide force by mass, the mass cancels, and without air resistance everything falls at about 9.8 metres per second squared.



10 / 12 · Myth: motion needs force

Here's a big misconception: a moving object needs a force to keep it moving. Not true. An object moving at constant velocity has zero net force. You only need a force to change velocity: to speed up, slow down or turn.

Force versus speed



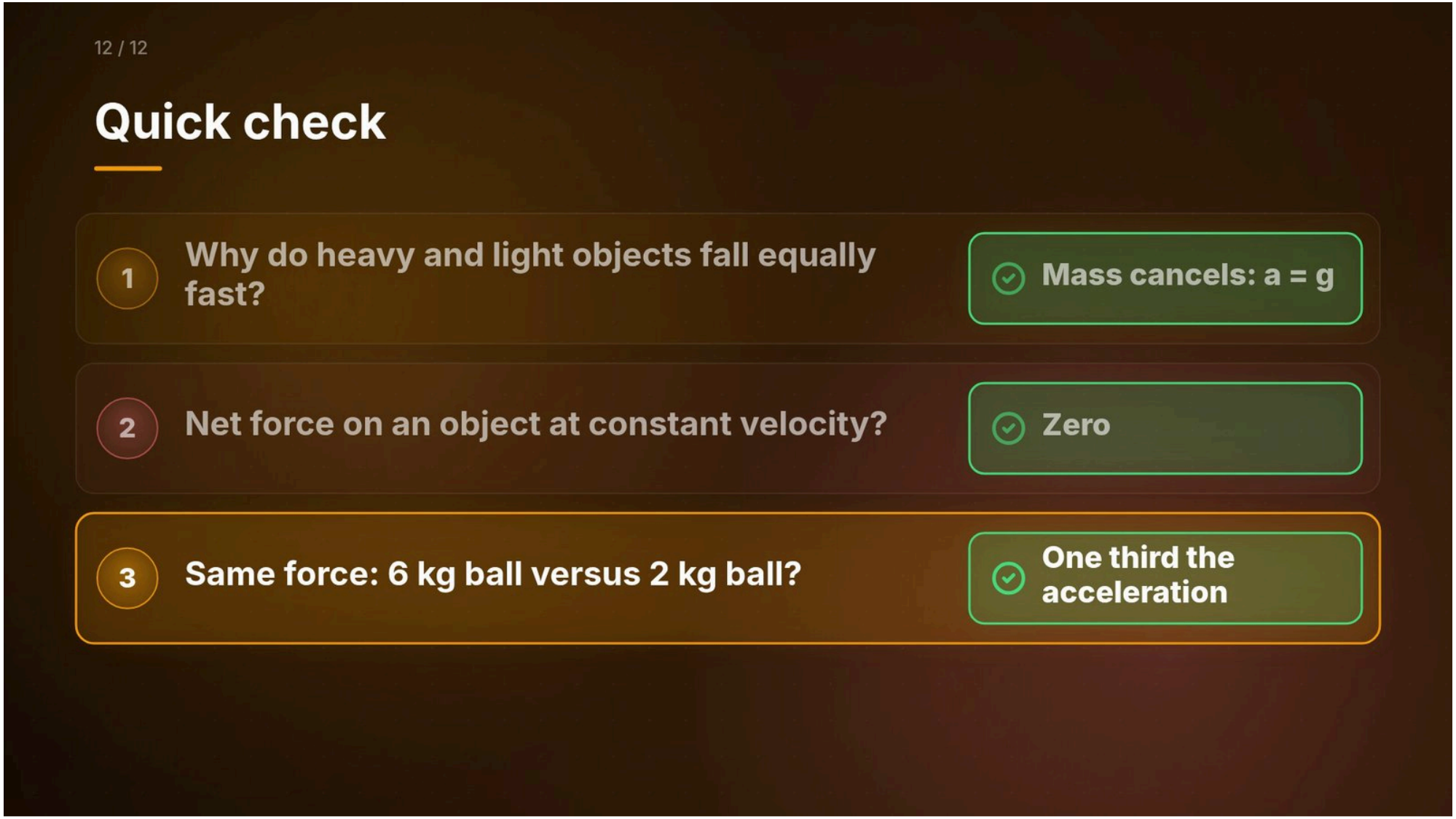
Big force, from rest

Small force, already moving

Slope = acceleration

Force sets acceleration, not speed

Another one: a bigger force always means a bigger speed. Not quite. Force sets the acceleration, which is the rate at which velocity changes. It doesn't set the speed itself.



12 / 12 · Check your understanding

Let's check what you learned. Why do heavy and light objects fall at the same rate, ignoring air resistance? The mass cancels, so they share the same acceleration, g. What is the net force on an object moving at constant velocity? Zero. The same net force acts on a 2 kilogram ball and a 6 kilogram ball. How does the heavier ball's acceleration compare? It's one third as large. Great work today, and see you next lesson!