Physics 20

Unit B: Forces and gravitation

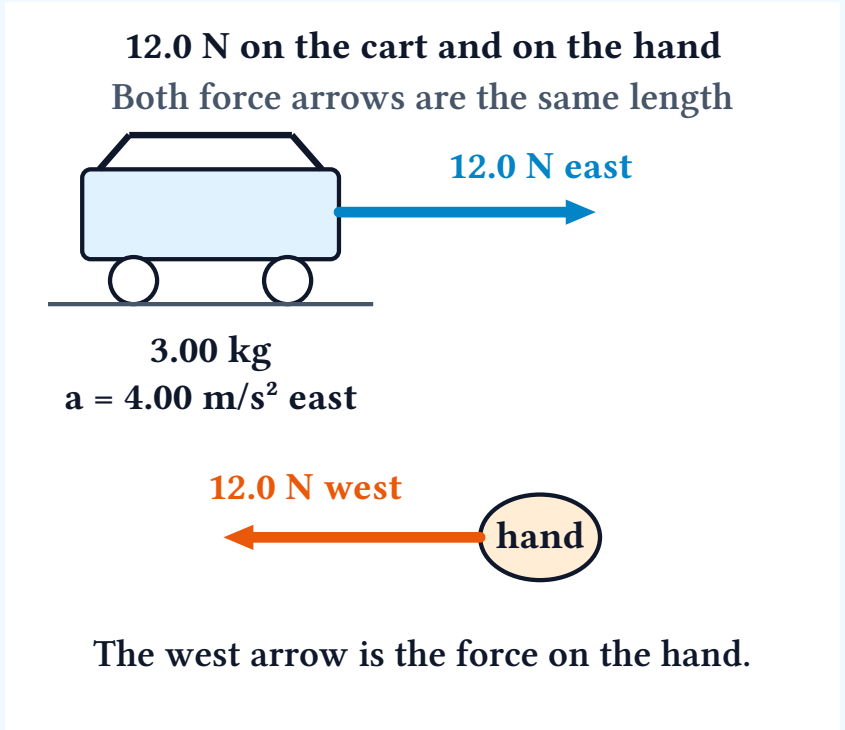
Newton’s second and third laws

A spring scale on a lab cart

- A spring scale pulls a 3.00 kg cart with 12.0 N east. That pull is the only horizontal force in the problem.
- The acceleration is 4.00 m/s squared east, and the student’s hand feels a matching pull west.

Newton's second and third laws

- F_{net} means the net force, m means the mass, and a means the acceleration.
- Newton's second law says F_{net} equals m times a.
- Newton's third law places equal magnitude forces on two different objects.
- A free body diagram keeps only the forces on the chosen object.



Key terms

Newton’s second law

Newton’s second law says the net force equals mass times acceleration, written $F_{net} = m\ a$. ($F_{net} = m\ a$)

Newton’s third law

Newton’s third law says the two forces in a pair have equal magnitude and opposite direction, and each force acts on a different object.

free body diagram

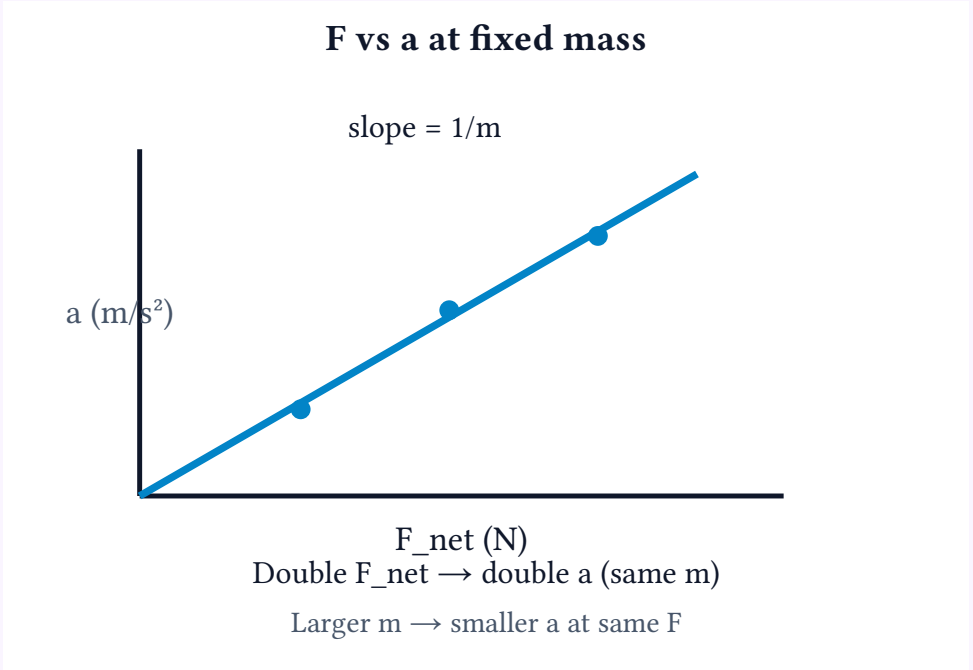
A free body diagram shows only the forces on the chosen object, drawn as arrows on a simple outline.

mass

Mass is the amount of matter in an object, measured in kilograms, and it sets how large an acceleration a given net force produces. (m)

Force and acceleration graph

- Same mass: double the net force and the acceleration doubles.
- At a fixed net force, a larger mass goes with a smaller acceleration.
- A timer supplies delta v over delta t for each run.

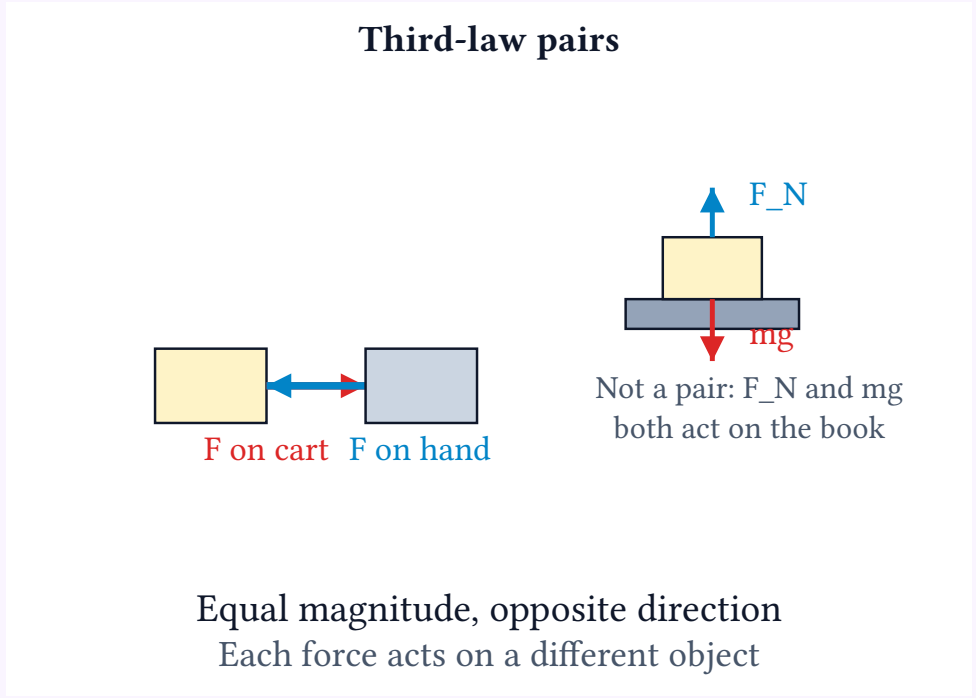


Three ways to state 4.00 m/s squared

- In numbers: the 3.00 kg cart gains 4.00 m/s squared east.
- In symbols: 12.0 N / 3.00 kg = 4.00 m/s^2 east.
- On a graph: the mass is the slope of the force versus acceleration line.

Partner forces land on different objects

- The two forces in the pair have equal magnitude and opposite direction.
- Each force acts on a different object, so the accelerations can differ.
- A free body diagram of a book shows weight and the normal force from the desk.



A wagon and a book outline

- A 2.50 kg wagon has a net force of 7.50 N forward.
- Find the acceleration and name the third law partner on the puller’s hand.
- List the forces on a free body diagram of a lunch bag sitting on a table.

Newton’s laws

- A 4.00 kg crate has a net force of 10.0 N south.
- Find the acceleration and the partner force on the rope.
- Name the forces on a free body diagram of the crate if the pull is horizontal on a level floor.