Chapter 2

Newton's First Law of Motion - Inertia

Objectives:

1) Aristotle’s Ideas of Motion
2) Galileo’s Concept of Inertia
3) Newton’s First Law of Motion
4) Net Force
5) The Equilibrium Rule
6) Support Force ,Normal Force
7) Equilibrium of Moving Things
8) The Moving Earth

Aristotle's Ideas of Motion

Aristotle's classification of motion:

2 main classes → Natural motion / Violent motion

- Natural motion

–Every object in the universe has a proper place determined by a combination of four elements: earth, water, air, and fire.

–Any object not in its proper place will strive to get there.

Examples:

•Stones fall.

•Puffs of smoke rise.

Aristotle's Ideas of Motion

•Natural motion (continued)

–Straight up or straight down for all things on Earth.

–Beyond Earth, motion is circular.

Example: The Sun and Moon continually circle Earth.

•Violent motion

–Produced by external pushes or pulls on objects.

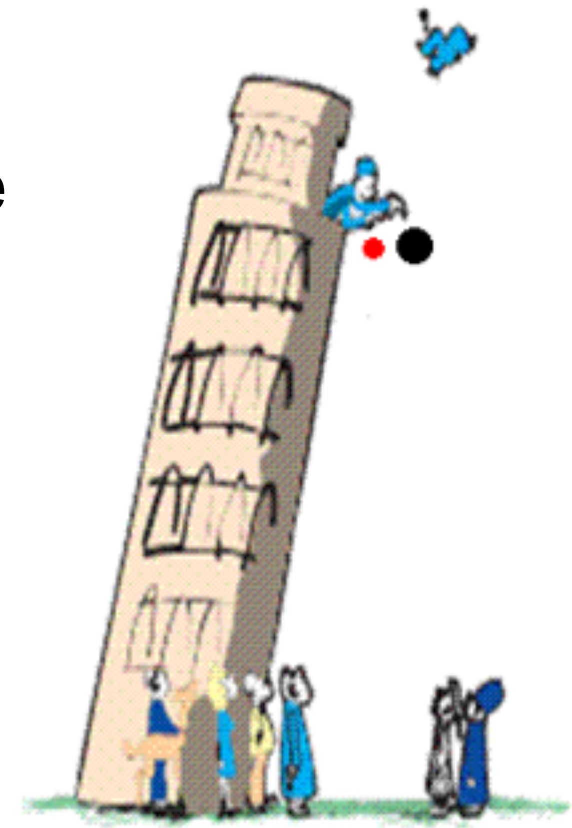
Example: Wind imposes motion on ships.

Galileo's Concept of Inertia

Galileo demolished Aristotle's assertions in the early 1500s.

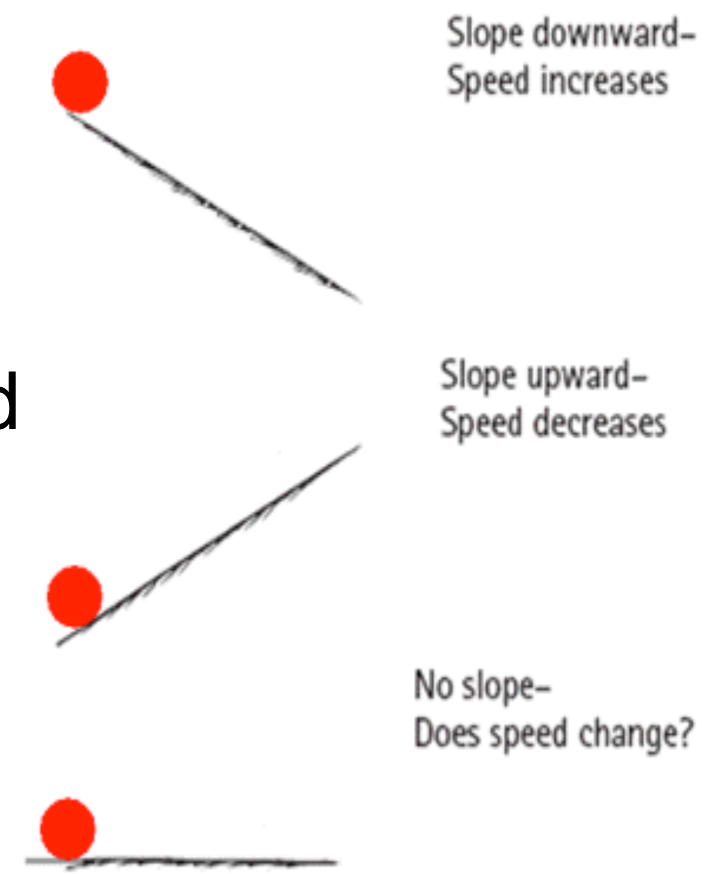
Galileo's discovery:

- Objects of different weight fall to the ground at the same time in the absence of air resistance.
- A moving object needs no force to keep it moving in the absence of friction.



Aristotle did not consider motion in a vacuum. -->
Therefore, an object needs a pull or push to keep moving.

Galileo denied this principle and stated that if there is no interference with a moving object, it will keep moving in a straight line forever; no push, pull and any kind of force is necessary.
In the absence of retarding forces, the object has a tendency to move forever without slowing down.



Galileo's experiment

The property of an object to resist changes in motion: **Inertia**

Galileo's Concept of Inertia

Inertia

- is a property of matter to resist changes in motion.
- depends on the amount of matter in an object (its *mass*).

The use of inclined planes for Galileo's experiments helped him to

A. eliminate the acceleration of free fall.
B. discover the concept of energy.
C. discover the property called inertia.
D. discover the concept of momentum.

The use of inclined planes for Galileo’s experiments helped him to

A. eliminate the acceleration of free fall.
B. discover the concept of energy.
C. **discover the property called inertia.**
D. discover the concept of momentum.

Comment:
Note that inertia is a *property* of matter, not a reason for the behavior of matter.

Newton’s First Law of Motion

Every object continues in a state of rest or of uniform speed in a straight line unless acted on by a nonzero net force.

Objects **<u>won’t</u>** move or change motion without a net force being applied

Net Force

Vector quantity

- a quantity whose description requires both magnitude (how much) and direction (which way)
- can be represented by arrows drawn to scale, called vectors

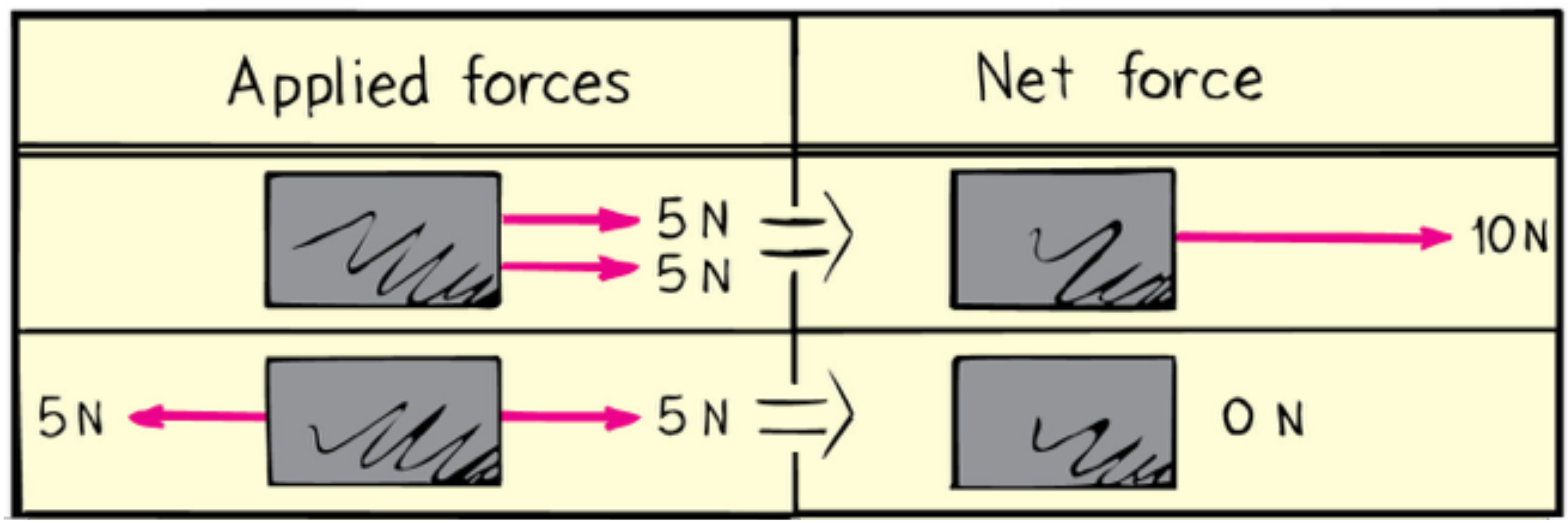
–length of arrow represents magnitude and arrowhead shows direction

Examples: force, velocity, acceleration

Net Force

Net force is the combination of all forces that change an object's state of motion.

Example: If you pull on a box with 10 N and a friend pulls oppositely with 5 N, the net force is 5 N in the direction you are pulling.



A cart is pushed to the right with a force of 15 N while being pulled to the left with a force of 20 N. The net force on the cart is

A. 5 N to the left.
B. 5 N to the right.
C. 25 N to the left.
D. 25 N to the right.

A cart is pushed to the right with a force of 15 N while being pulled to the left with a force of 20 N. The net force on the cart is

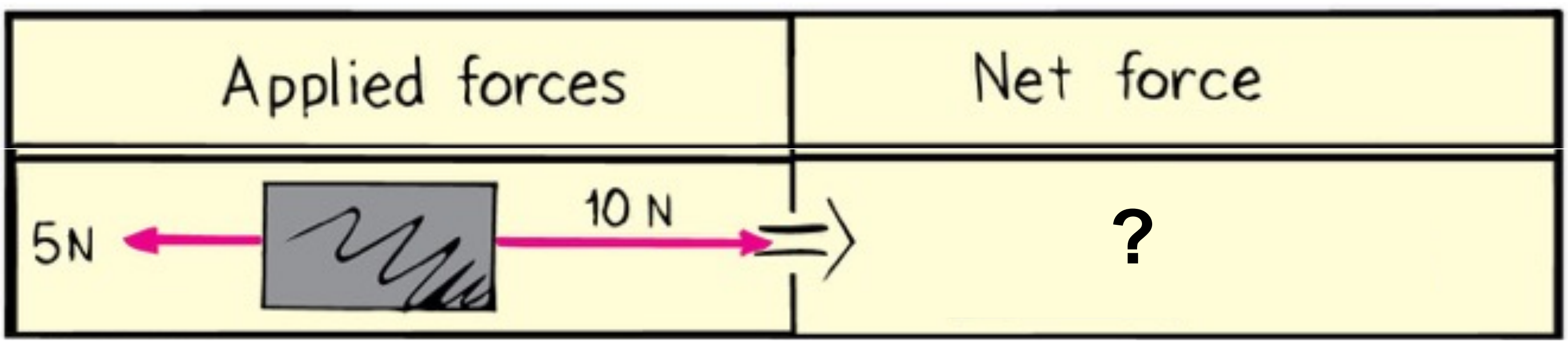
A. **5 N to the left.**
B. 5 N to the right.
C. 25 N to the left.
D. 25 N to the right.

Two forces are in opposite directions, so they subtract.

The direction is determined by the direction of the larger force.

What is the net force acting on the box?

A. 15 N to the left
B. 15 N to the right
C. 5 N to the left
D. 5 N to the right



What is the net force acting on the box?

A. 15 N to the left
B. 15 N to the right
C. 5 N to the left
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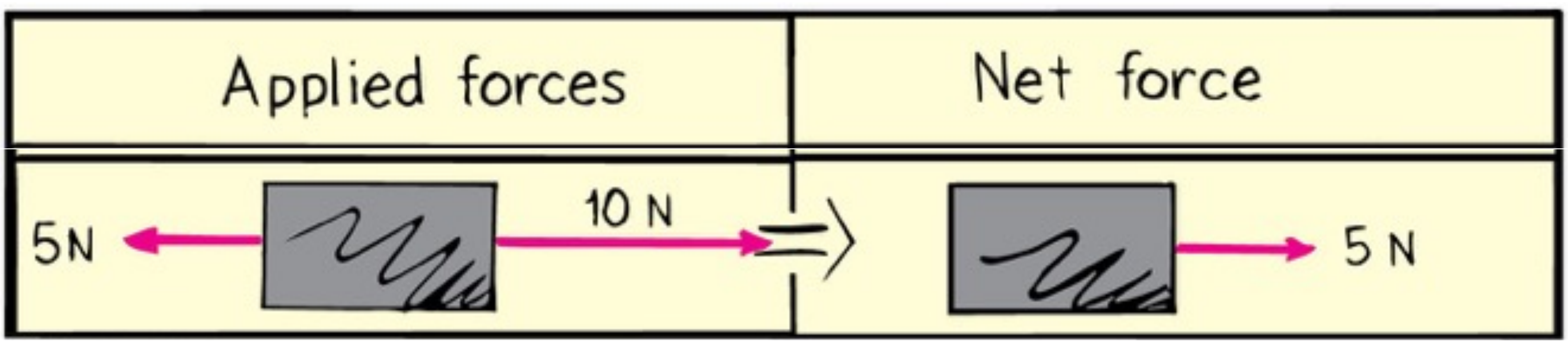
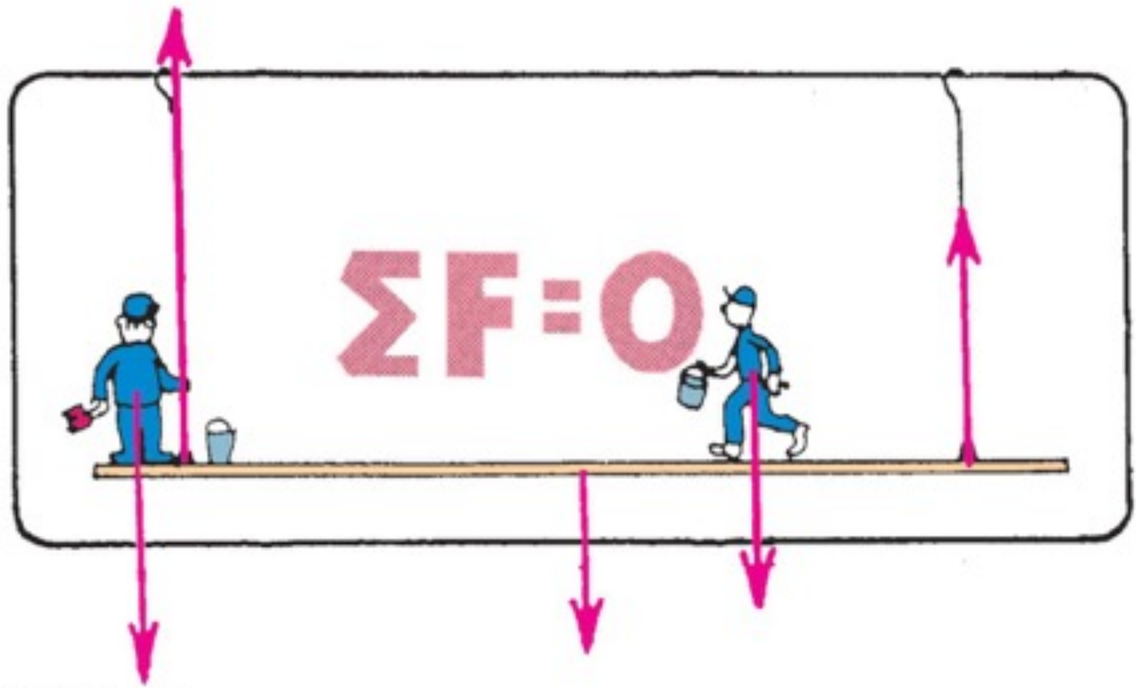


The Equilibrium Rule

- The vector sum of forces acting on a non-accelerating object equals zero.
- In equation form: $\Sigma F = 0$.



The Equilibrium Rule : Example

A string holding up a bag of flour

- Two forces act on the bag of flour:
  - Tension force acts upward.
  - Weight acts downward.
- Both are equal in magnitude and opposite in direction.
  - When added, they cancel to zero.
  - So, the bag of flour remains at rest.

The equilibrium rule, $\Sigma F = 0$, applies to

A. vector quantities.
B. scalar quantities.
C. Both of the above.
D. None of the above.

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A. **vector quantities.**
B. scalar quantities.
C. Both of the above.
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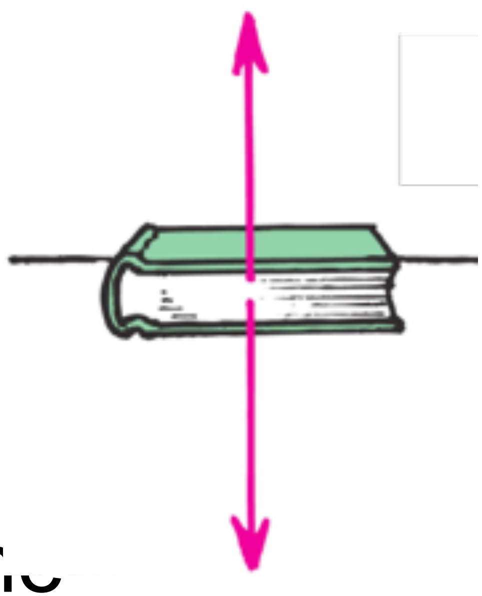
Explanation:
Vector addition accounts for + and – quantities.
So, two vectors in opposite direction can add to zero.

Support Force

Support force is an upward force on an object that is opposite to the force of gravity.

Example: A book on a table compresses Atoms in the table, and the compressed atoms produce the support force.

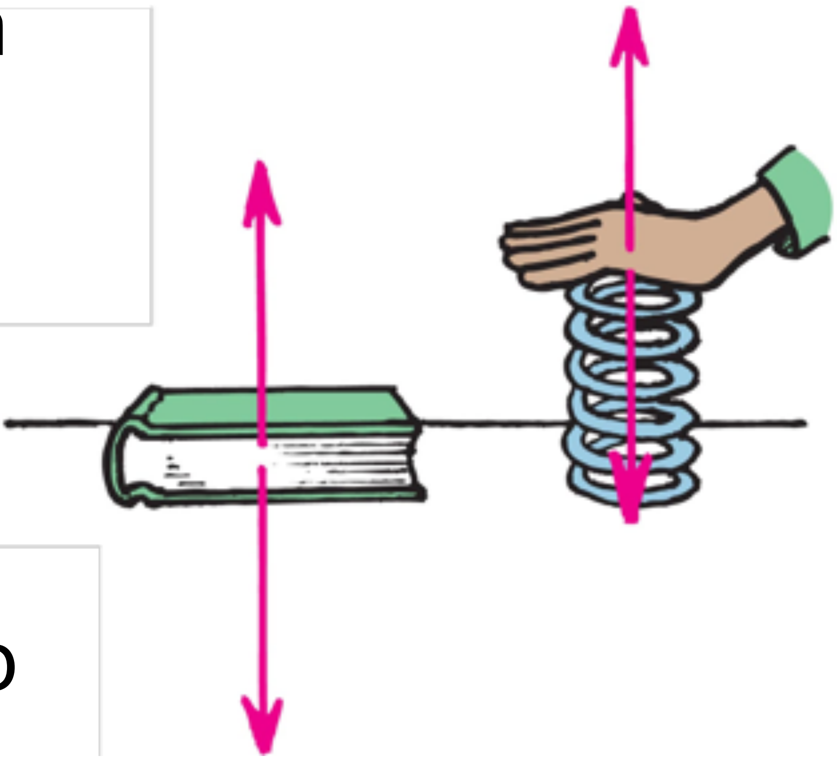


Normal force: component of support force perpendicular to the supporting surface.

Understanding Support Force

When you push down on a spring, the spring pushes back up on you.

Similarly, when a book pushes down on a table, the table pushes back up on the book.



When you stand on two bathroom scales with one foot on each scale and with your weight evenly distributed, each scale will read

A. your weight.
B. half your weight.
C. zero.
D. more than your weight.

When you stand on two bathroom scales with one foot on each scale and with your weight evenly distributed, each scale will read

A. your weight.
B. **half your weight.**
C. zero.
D. more than your weight.

Explanation:

- You are at rest, so ΣF=0.
- Forces from both scales add to cancel your weight.
- Force from each scale is one-half your weight

Equilibrium of Moving Things

Equilibrium: a state of no change with no net force acting.

- Static equilibrium

  Example: hockey puck at rest on slippery ice

- Dynamic equilibrium

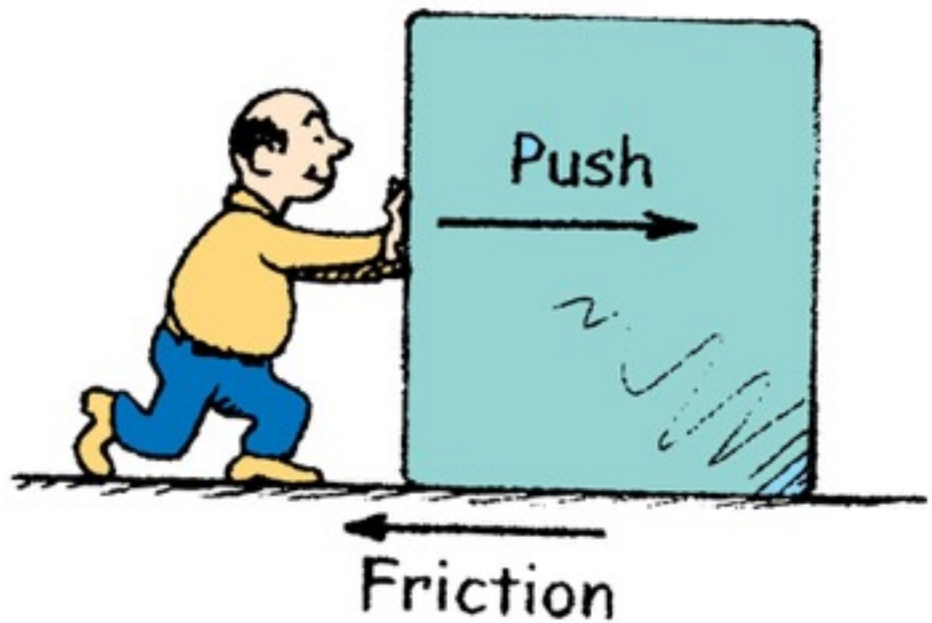
  Example: hockey puck sliding at constant speed on slippery ice

Equilibrium of Moving Things

Equilibrium test: whether something undergoes **changes** in motion.

Example: A crate at rest is in static equilibrium.

Example: When pushed at a steady speed, it is in dynamic equilibrium.



A bowling ball is in equilibrium when it

A. is at rest.
B. moves steadily in a straight-line path.
C. Both of the above.
D. None of the above.

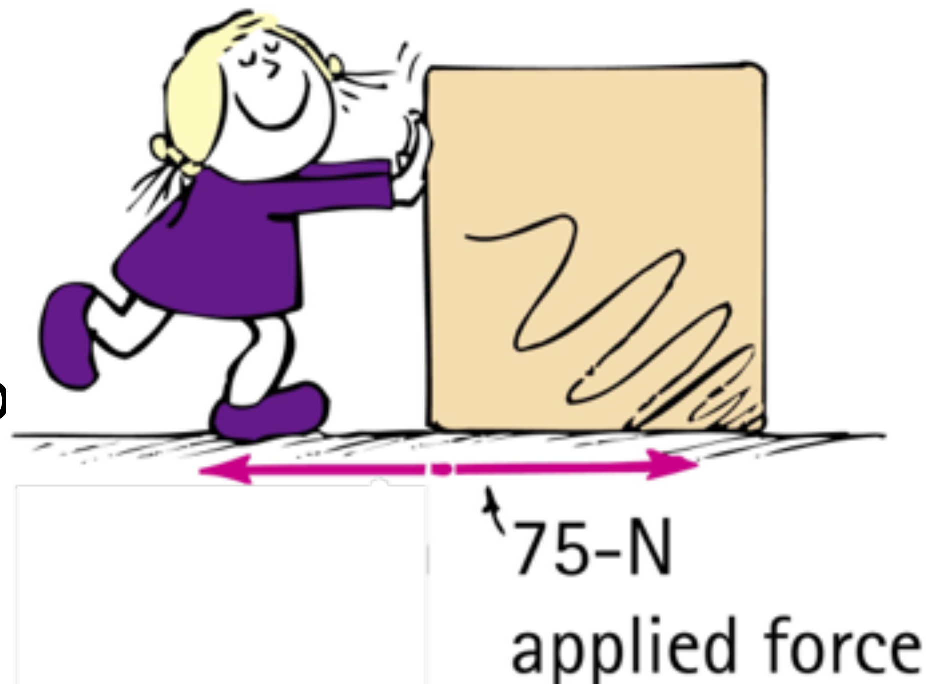
A bowling ball is in equilibrium when it

A. is at rest.
B. moves steadily in a straight-line path.
C. **Both of the above.**
D. None of the above.

Explanation:
Equilibrium means no change in motion, so there are two options:
- If at rest, it continues at rest.
- If in motion, it continues at a steady rate in a straight line.

You are pushing a crate at a steady speed in a straight line. If the friction force is 75 N, how much force must you apply?

A. more than 75 N
B. less than 75 N
C. equal to 75 N
D. not enough informatio



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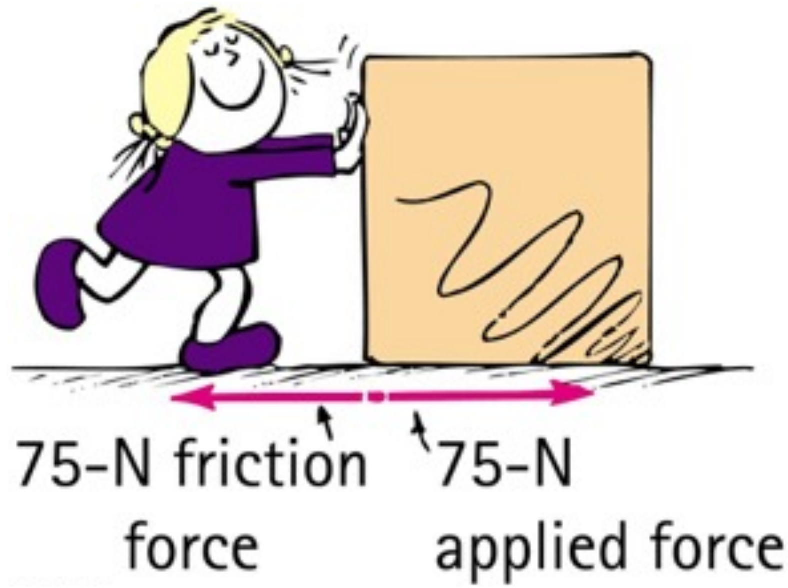


Explanation:
The crate is in dynamic equilibrium, so, $\Sigma F = 0$.
Your applied force balances the force of friction.

The Moving Earth

Copernicus proposed that Earth was moving.

- This idea was refuted by people.
- Example: If Earth moved, how can a bird swoop from a branch to catch a worm?
- Solution: As it swoops, due to inertia, it continues to go sideways at the speed of Earth along with the tree, worm, etc.

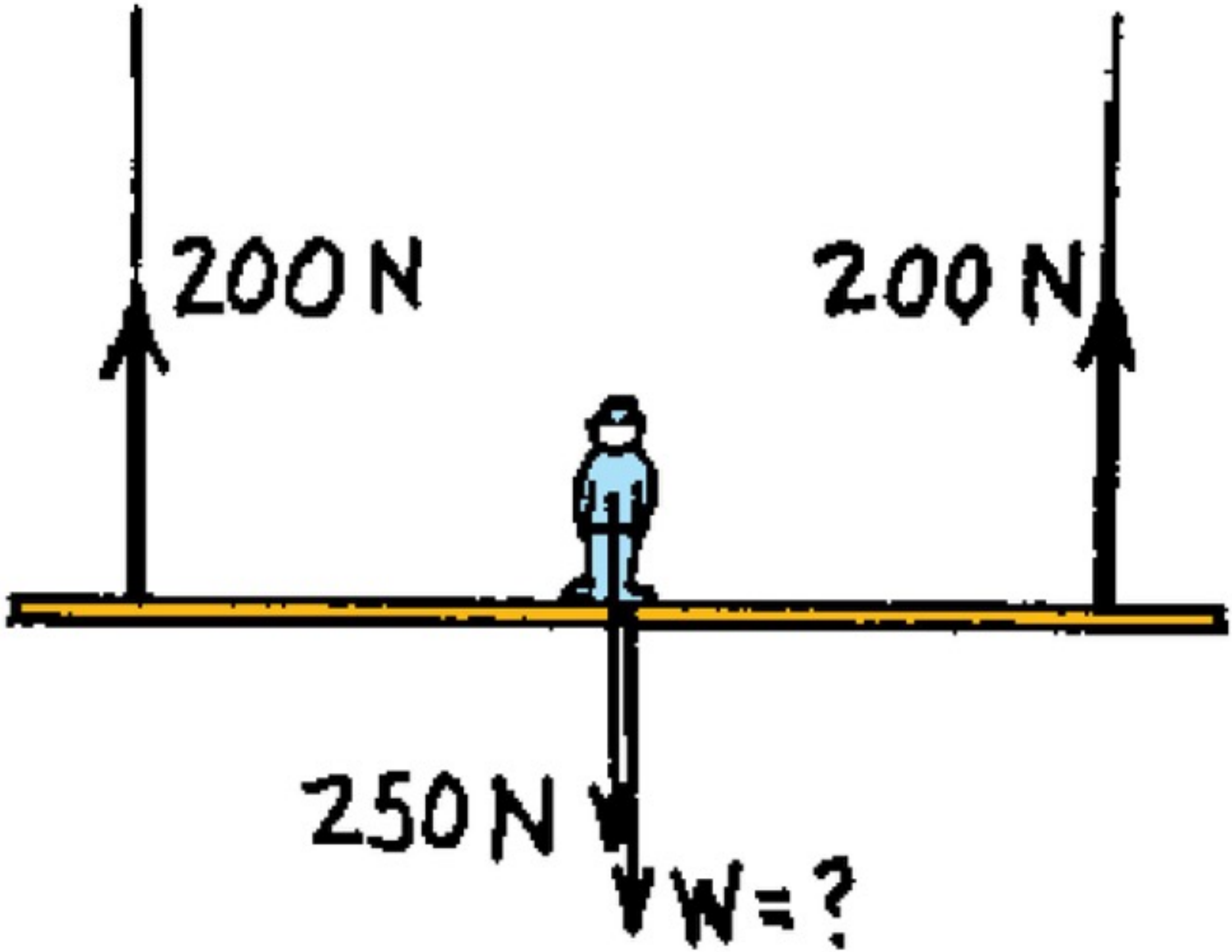
You are riding in a van at a steady speed and toss a coin up. Where will the coin land?

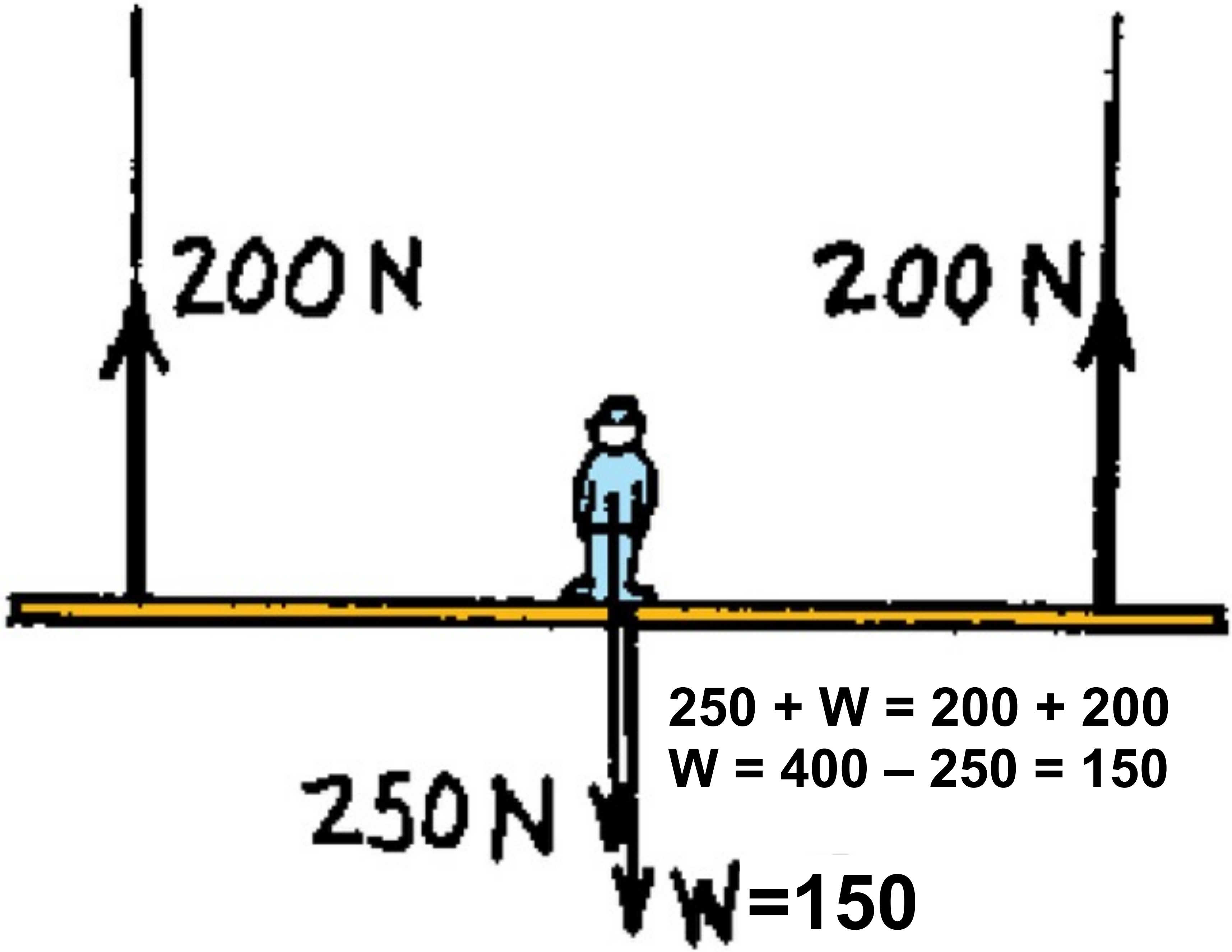
A. behind you
B. ahead of you
C. back in your hand
D. There is not enough information.

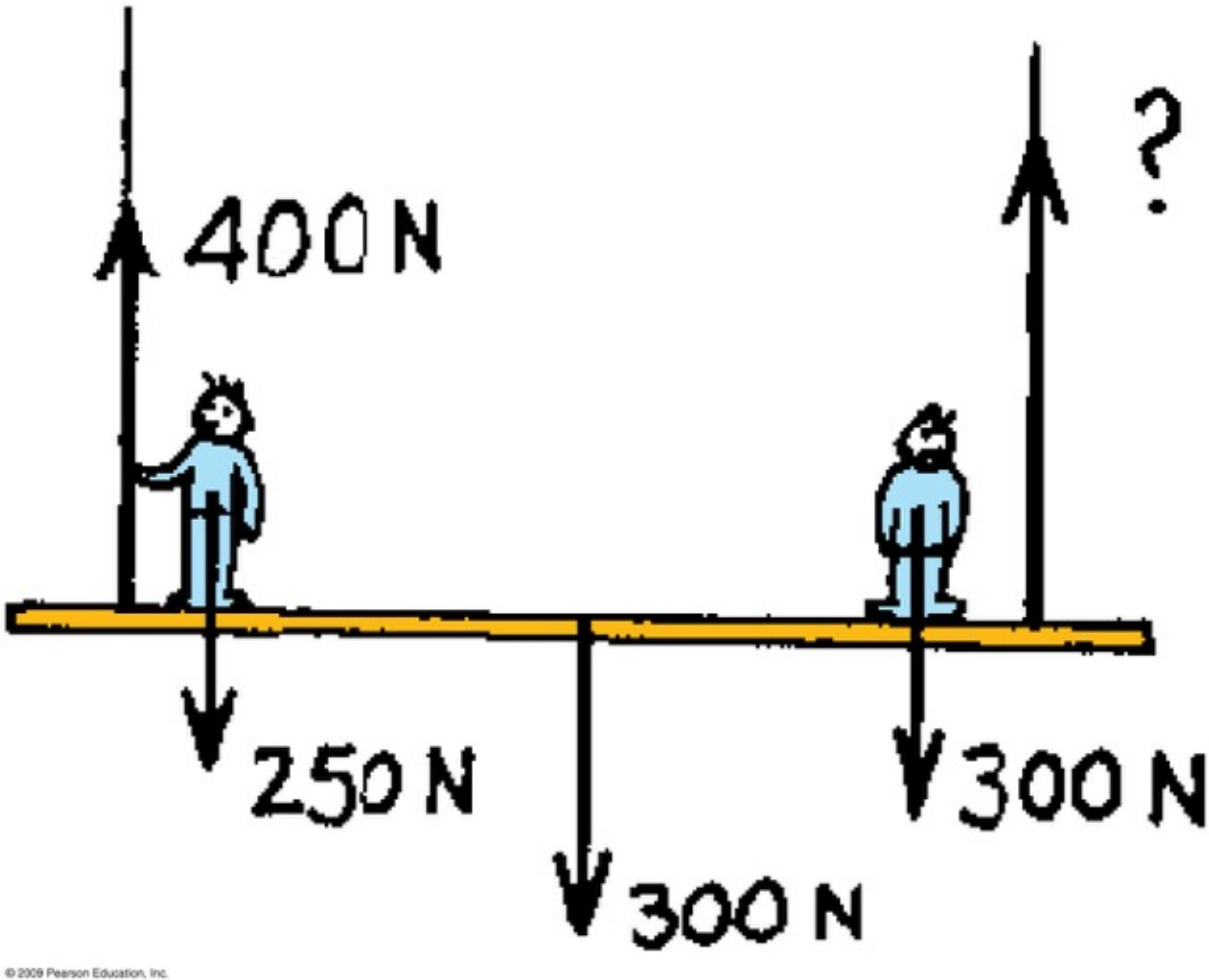
You are riding in a van at a steady speed and toss a coin up. Where will the coin land?

A. behind you
B. ahead of you
C. **back in your hand**
D. There is not enough information.

Explanation:
The coin has inertia. It continues sideways with the van and your hand and lands back in your hand.


200 N
200 N
250 N
W = ?


200 N
200 N
250 + W = 200 + 200
W = 400 – 250 = 150
250 N
W=150


400 N
?
250 N
300 N
300 N
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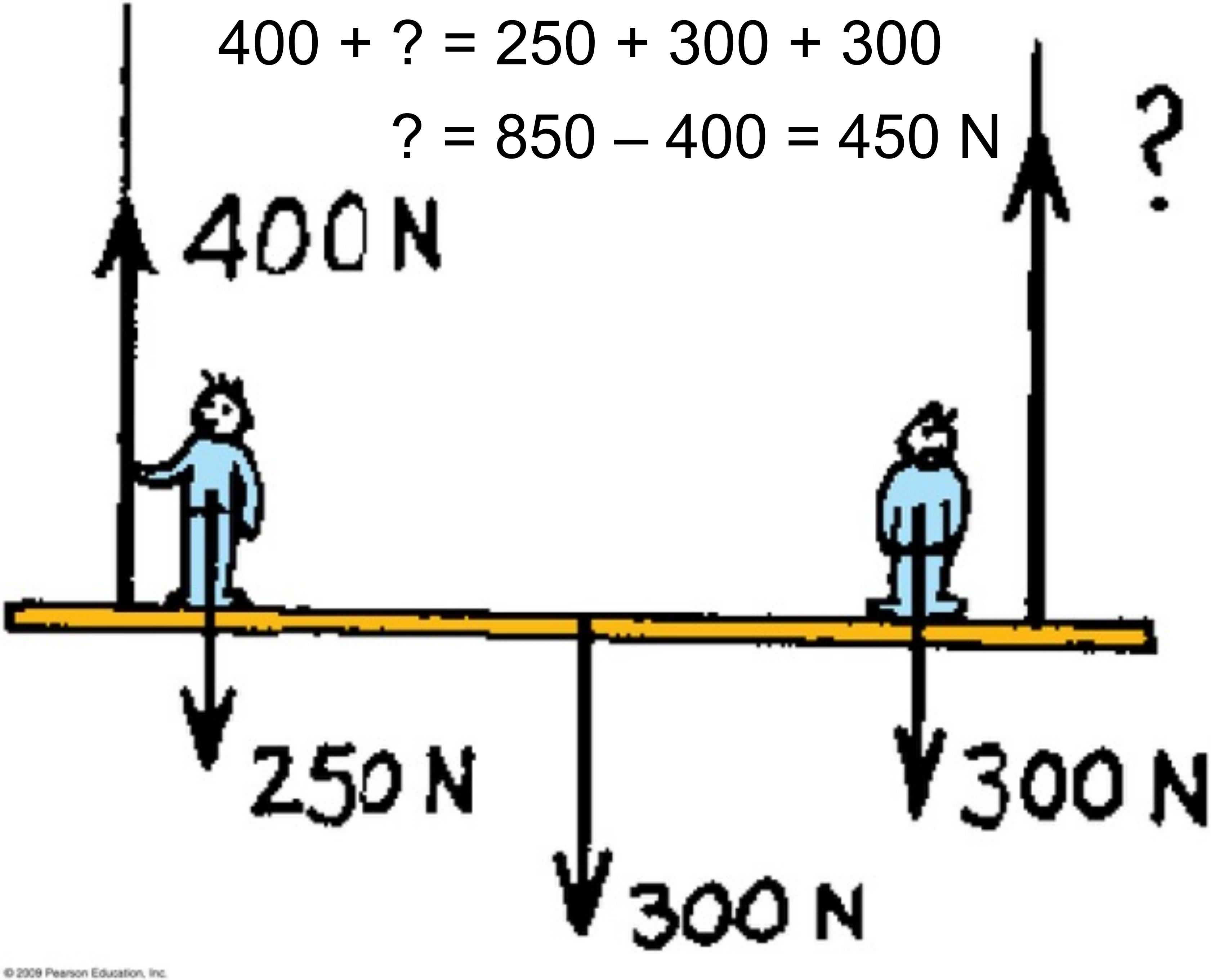
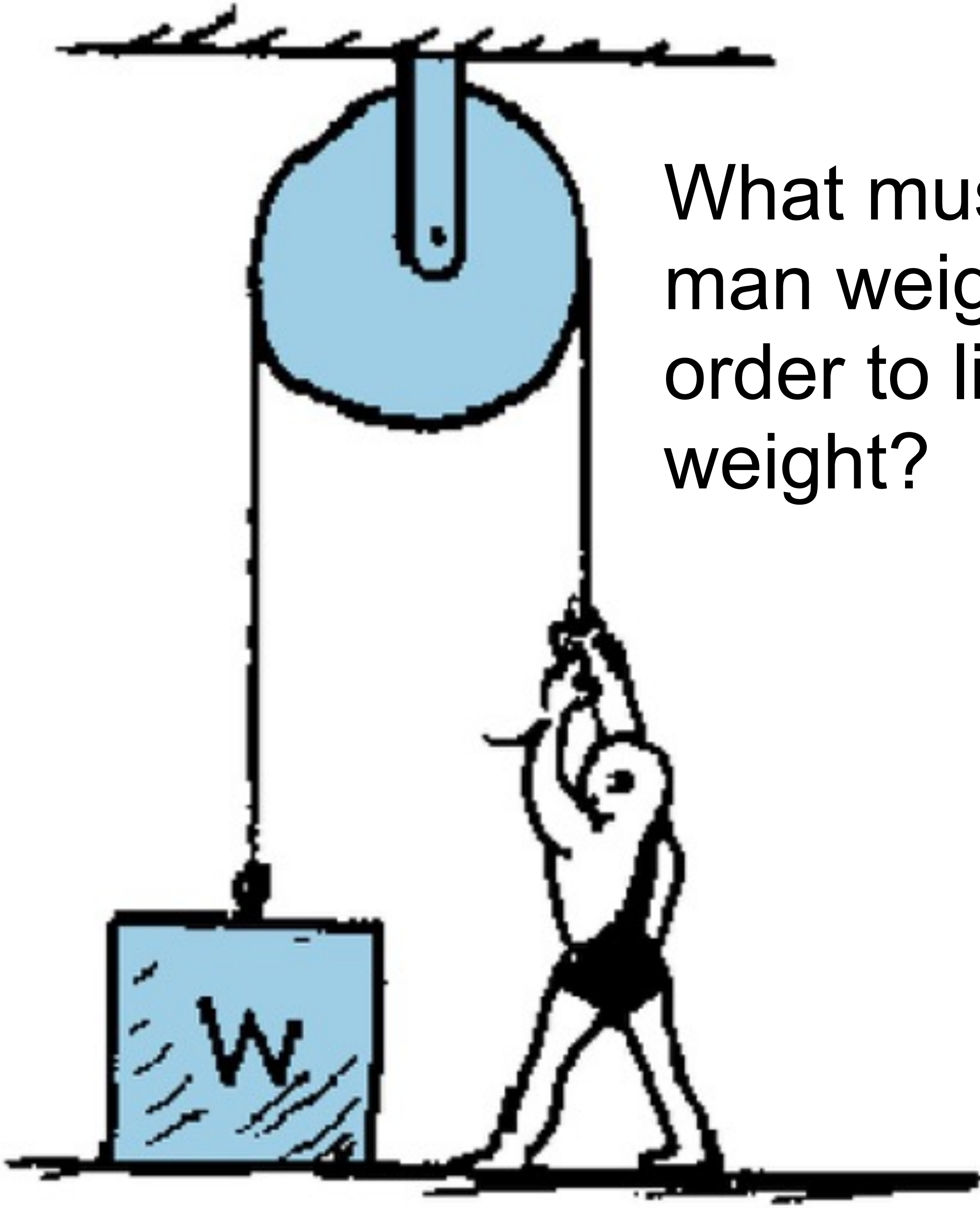
$$400 + ? = 250 + 300 + 300$$

$$? = 850 - 400 = 450 \text{ N}$$

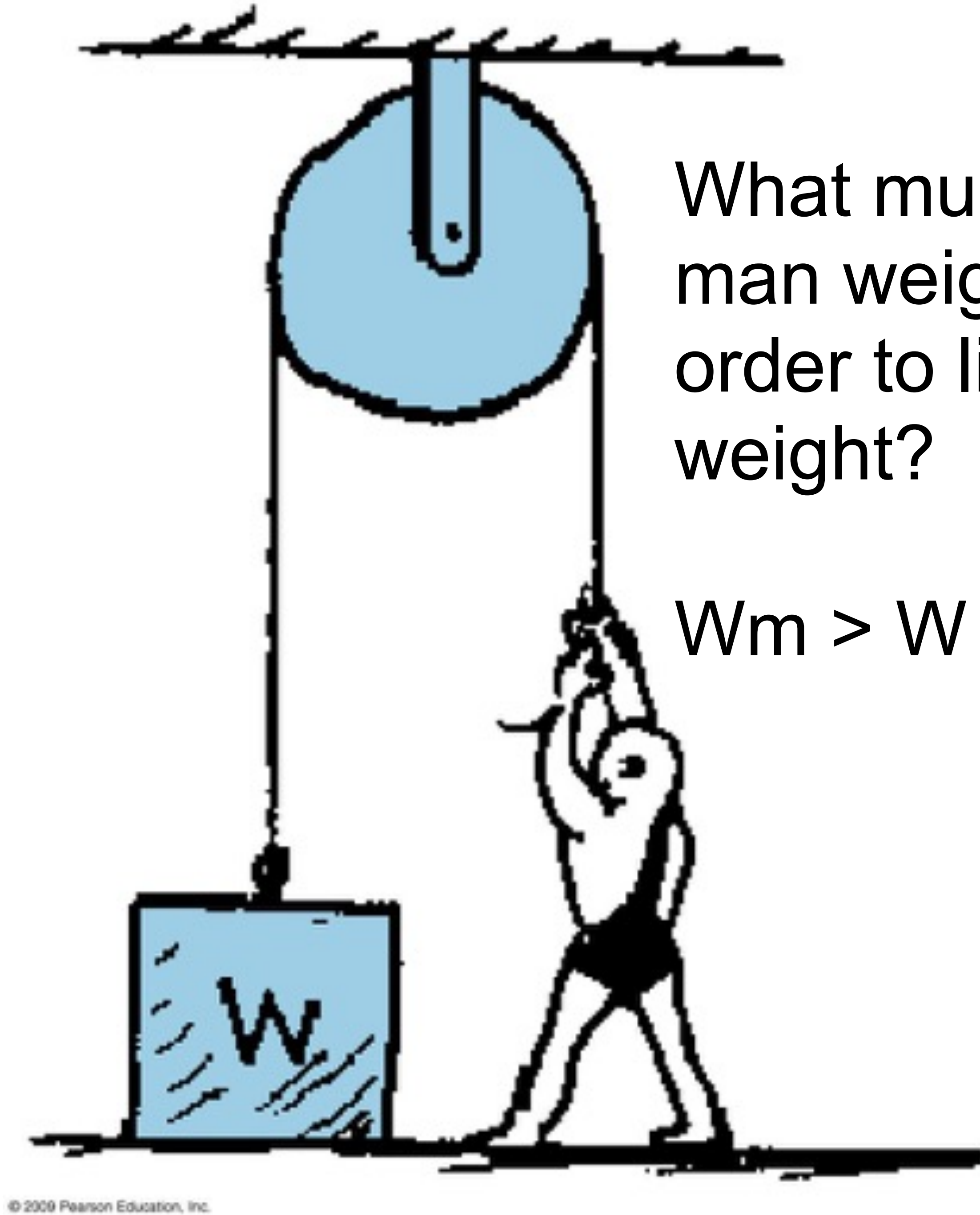


If the girl's weight is W, what is the reading on the scale?

= W / 2



What must the man weigh in order to lift the weight?



What must the man weigh in order to lift the weight?

Wm > W

Homework

- Read Chapter 2 in Detail.
- Do Ranking # 2
- Do Exercises 28, 32,40
- Do Problem 2

Homework due: May 23