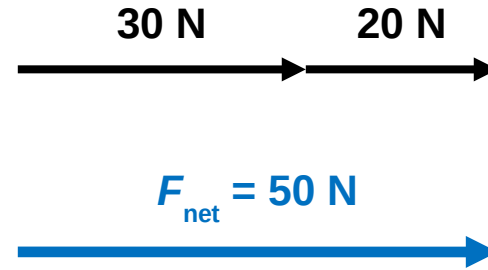


Essential Question

How do we combine all the forces on an object?

What Is Net Force?

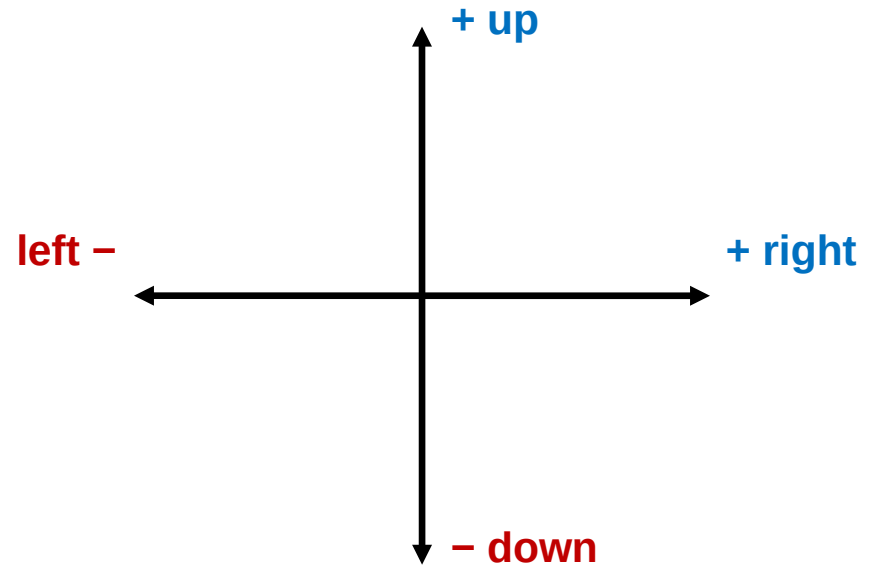
- The total of all forces
- Symbol: F_{net}
- Decides how motion changes



two pushes to the right add up

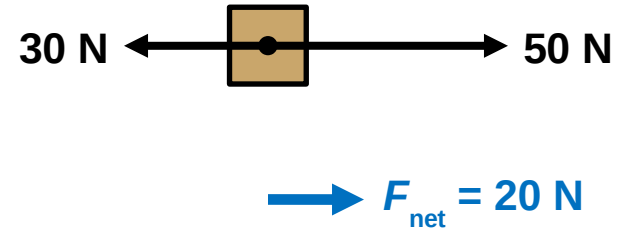
Signs Show Direction

- Right and up: positive (+)
- Left and down: negative (-)
- Add forces with their signs



Opposite Directions

- Opposite forces partly cancel
- Use + and - signs
- Net points toward the bigger force



$$+50 \text{ N} + (-30 \text{ N}) = +20 \text{ N}$$

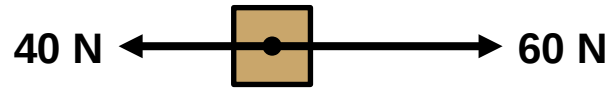
Balanced vs. Unbalanced

- Balanced: $F_{\text{net}} = 0$
- Unbalanced: $F_{\text{net}} \neq 0$
- Unbalanced forces change velocity

horizontal forces on a box



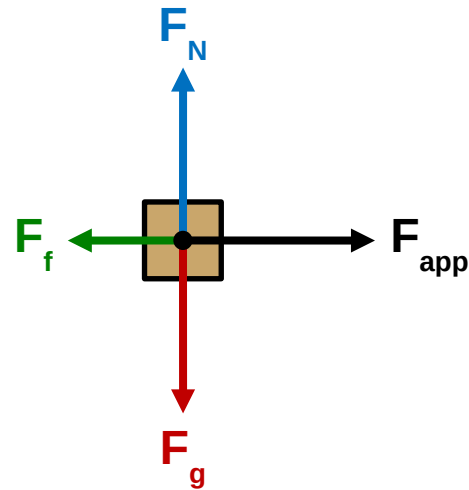
balanced: $F_{\text{net}} = 0$



unbalanced: $F_{\text{net}} = 20 \text{ N right}$

Writing the Net Force Equation

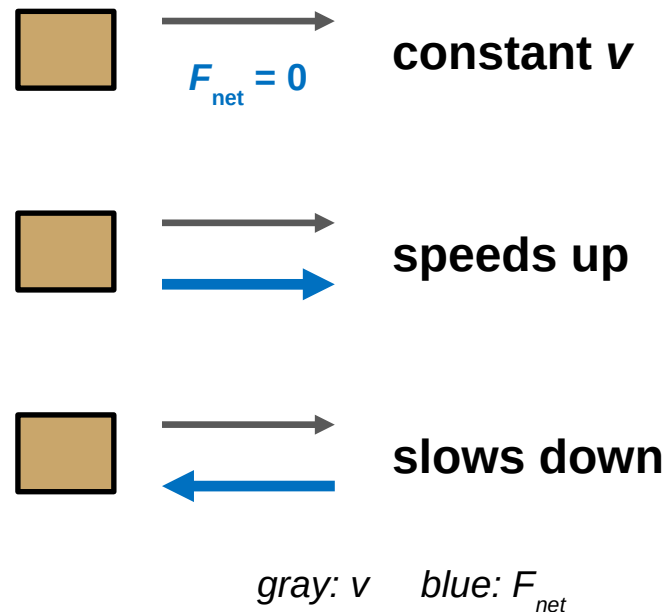
- One equation per direction
- Horizontal: $F_{\text{net}} = F_{\text{app}} - F_{\text{f}}$
- Vertical: $F_{\text{net}} = F_{\text{N}} - F_{\text{g}}$



+ right, + up

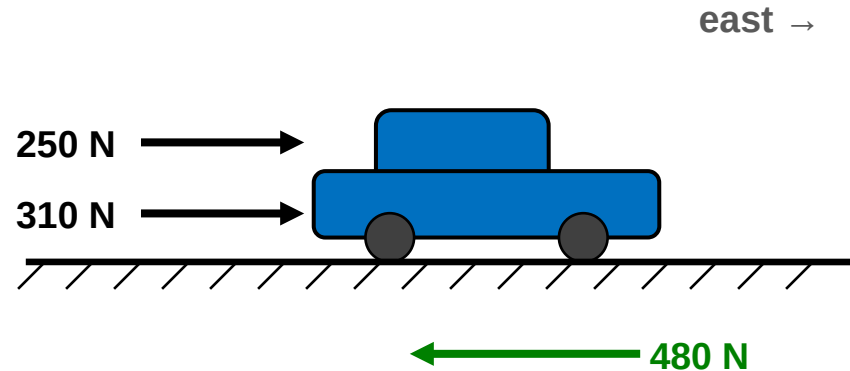
Predicting Motion

- $F_{\text{net}} = 0$: same velocity
- F_{net} with v : speeds up
- F_{net} against v : slows down



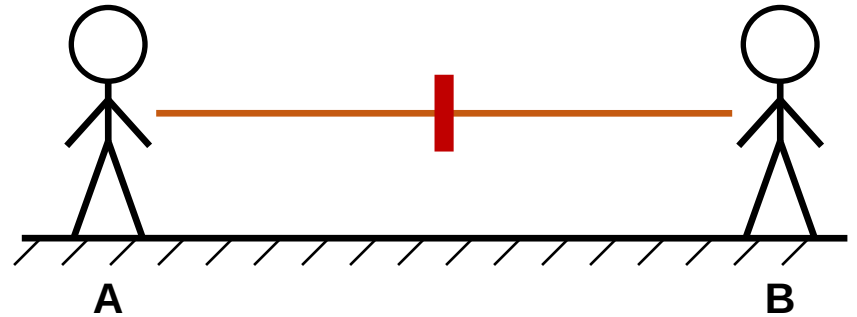
Example: Pushing a Stalled Car

Two students push a stalled car east, one with 250 N and the other with 310 N. Friction on the car is 480 N west. What is the net force on the car?



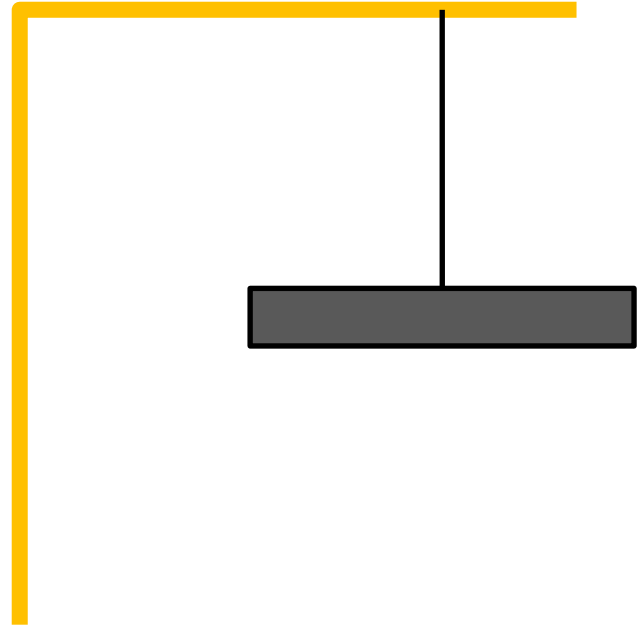
Example: Tug-of-War

In a tug-of-war, Team A pulls the rope west with 845 N. Team B pulls it east with 790 N. Find the net force on the rope. Which way does the rope start to move?



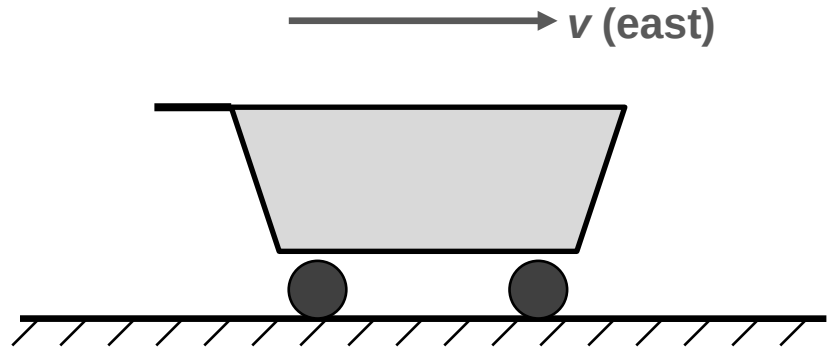
Example: Lifting a Beam

A crane cable pulls up on a 4,520 N steel beam with a tension of 4,850 N. Find the net force on the beam. If the beam starts at rest, what happens?



Example: A Rolling Cart

A shopper pushes a cart east with 35 N while friction acts on it with 35 N west. The cart is already moving east. Find the net force and describe the cart's motion.



Big Ideas

- Net force: the sum of all forces, with signs
- Balanced: $F_{\text{net}} = 0$. Unbalanced: $F_{\text{net}} \neq 0$
- Write F_{net} from the free-body diagram
- $F_{\text{net}} = 0$ means constant velocity