Net force: the formula, balanced against unbalanced forces, and free-body diagrams

The net (resultant) force is the one force with the same effect as all the forces on an object together. Add forces in a line with signs (one direction positive); combine perpendicular forces by Pythagoras. Zero net force: no change in motion (at rest, or constant velocity). Non-zero: acceleration a = F net / m, in the direction of the net force.

	Balanced forces	Unbalanced forces
Net force	zero	not zero
Motion	no change: at rest stays at rest, moving keeps the same velocity	speeds up, slows down or changes direction
Law	Newton's first	Newton's second: F net = m x a
Examples	book on a table; car at steady speed; skydiver at terminal velocity; tug of war at a standstill	dropped ball; car pulling away or braking; kicked football; rocket lifting off

Free-body diagram in four steps

[ ] Draw the object as a dot or box; nothing else
[ ] One arrow for each force acting ON the object, from the dot outward, longer for bigger
[ ] Label each: weight (mg, down), normal force (N, away from the surface), friction (f, against the motion), tension (T, along the rope), applied force (F), air resistance
[ ] Check: no arrow for 'motion' or 'speed'; no force the object exerts on something else

The forces

Force	Direction	Size
Weight, W = mg	straight down	mass x 9.8 N/kg (10 in many school problems)
Normal force, N	perpendicular to the surface, outward	whatever balances the forces into the surface
Friction, f	along the surface, opposing motion	up to mu x N
Tension, T	along the rope, away from the object	same throughout a light rope
Air resistance	opposite to the velocity	grows with speed

Worked examples

[ ] Push 40 N right, friction 15 N left, 5 kg box: F net = 25 N right; a = 25 / 5 = 5 m/s²
[ ] Lift rising at steady speed: tension 600 N up, weight 600 N down: F net = 0
[ ] 60 kg person in a lift accelerating up at 2 m/s²: F net = 120 N up, so the floor pushes 588 + 120 = 708 N
[ ] Car braking: 6,000 N backward on 1,200 kg: a = -5 m/s² (slowing)
[ ] Sled pulled 30 N north and 40 N east: F net = sqrt(900 + 1,600) = 50 N at 37° north of east; on 25 kg, a = 2 m/s²
[ ] Skydiver at terminal velocity: air resistance = weight, F net = 0, constant speed

From sciencewithshobha.com/blog/net-force-what-it-is-the-formula-balanced-against-unbalanced-forces-free-body-diagrams-how-to-find-the-net-force-in-one-and-two-dimensions-and-worked-examples/ · 1-on-1 online physics, chemistry and biology, KS3 to A level, Grades 6 to 12, free 30-minute first class.

The mistakes, the curriculum, and a practice set

Eight mistakes that lose marks

[ ] A moving object must have a net force on it (no: constant velocity means zero net force)
[ ] Adding opposite forces without signs (10 N and 4 N opposite = 6 N, not 14 N)
[ ] Drawing the object's push on the ground on the object's own diagram
[ ] Giving motion or speed an arrow
[ ] Normal force always equals weight (only on a flat surface with nothing else vertical)
[ ] Friction with the wrong sign (it opposes the motion)
[ ] Mass (kg) confused with weight (N): F = ma needs the mass
[ ] Perpendicular forces added as if in a line (3 N and 4 N make 5 N, not 7 N)

Curriculum	Where
US NGSS	MS-PS2-2 (Grades 6-8): sum of forces and mass; HS-PS2-1: F = ma with data
England	KS3 balanced and unbalanced; GCSE resultant force, F = ma, free-body and vector diagrams
Australia	Year 7 forces; Year 10 F = ma
CBSE	Class 8 Force and Pressure; Class 9 Force and Laws of Motion
Ontario	Grade 11 Physics SPH3U: forces in two dimensions

Practice

1. A 12 N push to the right and 7 N of friction to the left act on a box. Net force? Is the motion changing?
2. A 3 kg object has a net force of 18 N on it. Acceleration?
3. A parachutist falls at a constant 5 m/s; her weight is 700 N. Air resistance? Net force?
4. Forces of 6 N and 8 N act at right angles. Net force?
5. A 1,000 kg car accelerates at 3 m/s² against 500 N of resistance. Engine force?
6. A book slides right across a table and slows. Which way does the net force point, and which force is it?
7. Two children pull a rope with 150 N and 170 N in opposite directions. Net force and direction?
8. A 2 kg ball is in free fall (g = 9.8). Net force and acceleration?

Answers

1. 5 N right; yes, it accelerates right. 2. 6 m/s². 3. 700 N up; zero. 4. 10 N. 5. 3,500 N (3,000 for the acceleration + 500 to cancel resistance).

6. Left (backward); friction. 7. 20 N toward the 170 N child. 8. 19.6 N down; 9.8 m/s² down.

Your own problem

Object and chosen positive direction: _____

Forces (name, size, sign): _____

Net force (sum): _____

Mass and acceleration (a = F / m): _____

Check: direction and units: _____