2 Forces and Newton's laws – Part 1

Name: ____________ Class: ________ Date: __________

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	**中文**	**Write it 3 times** (English)		
force	力			
free-body diagram	受力图			
Weight	重力			
Newton's first law	牛顿第一定律			
inertia	惯性			
net force	合力			
equilibrium	平衡			
Newton's second law	牛顿第二定律			
Newton's third law	牛顿第三定律			

Recall

You have met forces before. Bring these ideas with you:

- A **force** is a push or a pull, measured in newtons (N).
- Gravity pulls things down; a table pushes up; a rope pulls along its length.
- You know that a heavier object is harder to get moving. At AP we make this exact with **Newton's laws**.

Nothing here is harder than what you already know – we just line it up carefully and draw good diagrams.

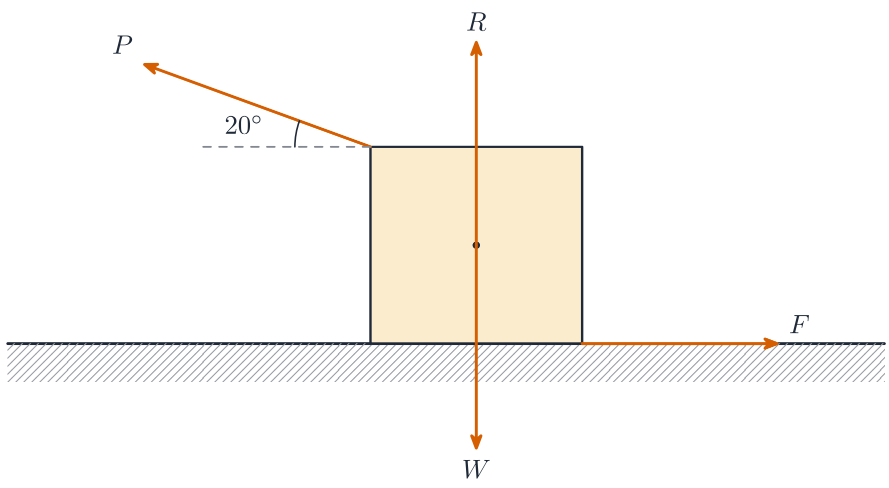
New ideas

Read these first. Each idea has a short worked example. Then do the Practice below.

■ 1 Force and the free-body diagram

A **force** 力 is a push or pull. It is a vector, so it has a size **and** a direction.

To solve any force problem, first draw a **free-body diagram** 受力图: show the object as a dot, then draw an arrow for **every** force acting **on** it – weight down, the surface's push, any rope or hand.



Two rules keep it honest: draw only forces acting **on** your object (not forces it pushes on other things), and draw only **real** forces (a rope, a surface, gravity) – never an "ma" arrow.

■ 2 Weight

Weight 重力 is the force of gravity on an object: $F_g = mg$, pointing down. Here m is the mass and $g = 9.8\ \mathrm{m/s^2}$ near Earth.

Worked example. A 2.0 kg bag has weight $F_g = mg = 2.0 \times 9.8 = 19.6$ N. On the Moon ($g = 1.6\ \mathrm{m/s^2}$) the same bag weighs only $2.0 \times 1.6 = 3.2$ N – but its **mass** is still 2.0 kg.

■ 3 Newton's first law

Newton's first law 牛顿第一定律 (the law of **inertia** 惯性): an object keeps a constant velocity unless a **net force** 合力 acts on it. So if the forces balance to zero, the object stays at rest or keeps moving at steady speed – it is in **equilibrium** 平衡.

Worked example. A car moves at a steady 25 m/s. Because the velocity is constant, the net force is zero – the engine's push exactly balances friction and air drag.

■ 4 Newton's second law

When the net force is **not** zero, the object accelerates: **Newton's second law** 牛顿第二定律 says

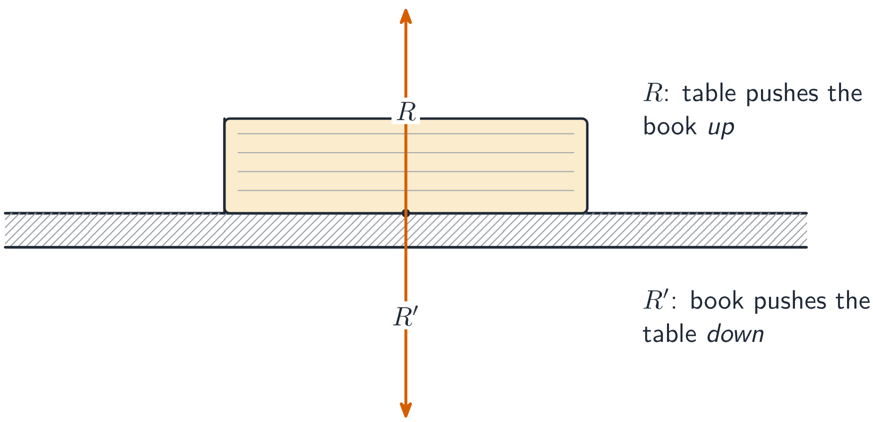
$$a = \frac{\sum F}{m}, \qquad \text{so} \qquad \sum F = ma.$$

The acceleration points the same way as the net force.

Worked example. A 4.0 kg box is pulled with 18 N while friction pulls back 6.0 N. The net force is $18 - 6.0 = 12$ N, so $a = \dfrac{12}{4.0} = 3.0\ \mathrm{m/s^2}$.

■ 5 Newton's third law

Newton's third law 牛顿第三定律: if A pushes on B, then B pushes back on A with an **equal and opposite** force.



The two forces act on **different** objects, so they never cancel.

Watch out: a book's weight and the table's push on the book are **not** a third-law pair – they act on the **same** object (the book). A third-law pair is always "A on B" with "B on A."

Practice

Try these in order. The methods are all above.

2.1 State the size and direction of the weight of a 3.0 kg book ($g = 9.8$ m/s^2). [2]

2.2 A box rests on a table. Name the two forces on the box and state their directions. [2]

2.3 A 6.0 kg trolley is pushed with a net force of 18 N. Find its acceleration. [2]

2.4 A lift moves upward at a **constant** speed. What is the net force on it? Explain. [2]

2.5 A 2.0 kg ball is pulled by a 10 N force while a 4.0 N friction force opposes it. Find the acceleration. [2]

2.6 A student says "the ground pushes up on my feet, and my feet push down on the ground – these cancel out, so I feel nothing." State what is wrong with this reasoning. [2]