

2.5 Newton's Second Law

Name: _____ Class: _____ Date: _____

Total: 16 marks**KEY WORDS** newton's second law 牛顿第二定律 • friction 摩擦力 • force 力 • net force 合力 • free-body diagram 自由体图

Objective

Build the skills to answer exam questions on **Newton's second law**.

You must be able to:

- apply **Newton's second law** 牛顿第二定律: $\vec{F}_{net} = m\vec{a}$
- find acceleration from a net force, or net force from an acceleration
- solve for one unknown among force, mass, and acceleration
- combine with free-body diagrams to find the net force first

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The core equation

$$\vec{F}_{net} = m\vec{a}.$$

A 4 kg block with a net force of 12 N accelerates at

$$a = \frac{F_{net}}{m} = \frac{12}{4} = 3 \text{ m s}^{-2}.$$

■ Find the force

Rearrange: $F_{net} = ma$. A 2 kg ball accelerating at 5 m s^{-2} needs $F_{net} = 2 \times 5 = 10 \text{ N}$.

■ Use the net force

First combine the forces, then apply $F_{net} = ma$. A 3 kg box pulled by 20 N against 8 N of friction: $F_{net} = 12 \text{ N}$, so $a = 12/3 = 4 \text{ m s}^{-2}$.

2 Practice

Now apply the methods above.

2.1 A net force of 18 N acts on a 6 kg mass. Find the acceleration. [2]

2.2 A 3 kg object accelerates at 4 m s^{-2} . Find the net force. [2]

2.3 A 10 N net force gives an acceleration of 2 m s^{-2} . Find the mass. [2]

2.4 A 5 kg crate is pushed by 25 N against 10 N friction. Find the acceleration. [2]

3 Exam-style questions

3.1 For a fixed net force, doubling the mass [1]

- A doubles the acceleration
- B halves the acceleration
- C leaves the acceleration unchanged
- D quadruples the acceleration

3.2 A 2 kg ball has a net force of 6 N. Its acceleration is [1]

- A 12 m s^{-2}
- B 3 m s^{-2}
- C 8 m s^{-2}
- D 0.33 m s^{-2}

3.3 A 1200 kg car speeds up at 2.5 m s^{-2} .

(a) Find the net driving force. [2]

(b) State what happens to the acceleration if the same force acts on a heavier car. [1]

3.4 A 2 kg block on a frictionless surface is pulled by two horizontal forces: 12 N right and 4 N left.

(a) Find the net force. [1]

(b) Find the acceleration. [2]

Solutions

2.1 $a = F/m = 18/6 = 3 \text{ m s}^{-2}$.

2.2 $F = ma = 3 \times 4 = 12 \text{ N}$.

2.3 $m = F/a = 10/2 = 5 \text{ kg}$.

2.4 $F_{\text{net}} = 25 - 10 = 15 \text{ N}$; $a = 15/5 = 3 \text{ m s}^{-2}$.

3.1 B — $a = F/m$, so doubling m halves a .

3.2 B — $a = 6/2 = 3 \text{ m s}^{-2}$.

3.3 (a) $F = ma = 1200 \times 2.5 = 3000 \text{ N}$. (b) It decreases (more mass, less acceleration for the same force).

3.4 (a) $12 - 4 = 8 \text{ N}$. (b) $a = 8/2 = 4 \text{ m s}^{-2}$.