Exercise walk-through

Forces and Free-Body Diagrams ▪ 2.2

eXercise

You must be able to

- identify the forces acting on an object (weight, normal, tension, friction, applied)
- draw a **free-body diagram 受力图** showing each force as an arrow from the object
- find the **net force 净力** by adding forces as vectors
- resolve forces into components on an inclined surface

Method — Identify every force

A book resting on a table feels two forces: its **weight** mg down and the **normal force** N up from the table. They balance, so the net force is zero.

Method — Draw the free-body diagram

Represent the object as a dot and draw one arrow per force, pointing the way the force acts, longer for bigger. Only forces *on* the object appear — never forces it exerts on others.

Method — Net force by components

Add forces as vectors. A box pulled right with 10 N while friction pulls left with 4 N:

$$F_{\text{net}} = 10 - 4 = 6 \text{ N to the right.}$$

Method — Forces on an incline

On a slope of angle θ, gravity splits into $mg\sin\theta$ (down the slope) and $mg\cos\theta$ (into the slope, balanced by the normal force).

Practice 2.1 ▪ 2 marks

A book rests on a table. Name the two forces acting on it.

Solution 2.1

Method: Identify every force

Worked steps

Weight (mg, down) and the normal force (N, up) B1 B1.

Practice 2.2 ▪ 2 marks

A box is pushed right with 20 N; friction opposes with 8 N. Find the net force.

Solution 2.2

Method: Net force by components

Worked steps

$20 - 8 = 12$ N to the right **M1** **A1**.

Practice 2.3 ▪ 1 mark

On a free-body diagram, whose forces are shown — those on the object, or those the object exerts?

Solution 2.3

Method: Draw the free-body diagram

Worked steps

The forces acting *on* the object B1.

Practice 2.4 ▪ 2 marks

A 2 kg block sits on a 30° incline. Find the component of gravity along the slope (use $g = 10$ m s^{-2}).

Solution 2.4

Method: Forces on an incline

Worked steps

$mg\sin\theta = 2(10)\sin 30^\circ = 10$ N (M1) (A1).

Exam-style 3.1 ▪ 1 mark

The net force on an object is the

A largest single force

B vector sum of all forces on it

C sum of its weight and mass

D force it exerts on the ground

Solution 3.1

Method: Draw the free-body diagram

A largest single force

B vector sum of all forces on it ✓

C sum of its weight and mass

D force it exerts on the ground

Worked steps

B — the net force is the vector sum of all forces on the object.

Exam-style 3.2 ▪ 1 mark

A free-body diagram should show

A only the weight

B all forces acting on the object

C the object's velocity

D forces the object exerts on others

Solution 3.2

Method: Draw the free-body diagram

A only the weight

B all forces acting on the object ✓

C the object's velocity

D forces the object exerts on others

Worked steps

B — all forces acting on the object.

Exam-style 3.3 ▪ 2 marks

A 5 kg crate is pulled right by 30 N against 12 N of friction.
(a) Find the net force.
(b) Find the acceleration.

Solution 3.3

Method: Net force by components

Worked steps

(a) $30 - 12 = 18$ N **M1** **A1**. (b) $a = F/m = 18/5 = 3.6$ m s^{-2} **B1**.

Exam-style 3.4 ▪ 2 marks

A 4 kg block rests on a 37° frictionless incline ($g = 10$ m s^{-2}).
(a) Find the component of gravity along the slope.
(b) Find the block's acceleration down the slope.

Solution 3.4

Method: Forces on an incline

Worked steps

(a) $mg\sin\theta = 4(10)\sin 37^\circ = 24$ N M1 A1. (b) $a = g\sin\theta = 6$ m s^{-2} B1.