AP PHYSICS C: MECHANICS • EXERCISE SHEET

2.2 Forces and Free-Body Diagrams

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

KEY WORDS friction 摩擦力 • tension 张力 • free-body diagram 受力图 • net force 净力 • force 力

Objective

Build the skills to answer exam questions on **forces and free-body diagrams**.

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

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.

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.

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.

Net force by components

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

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

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).

2 Practice

Now apply the methods above.

2.1 A book rests on a table. Name the two forces acting on it. [2]

2.2 A box is pushed right with 20 N; friction opposes with 8 N. Find the net force. [2]

2.3 On a free-body diagram, whose forces are shown — those on the object, or those the object exerts? [1]

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

3 Exam-style questions

3.1 The net force on an object is the [1]

- **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

3.2 A free-body diagram should show [1]

- **A** only the weight
- **B** all forces acting on the object
- **C** the object's velocity
- **D** forces the object exerts on others

3.3 A 5 kg crate is pulled right by 30 N against 12 N of friction.

(a) Find the net force. [2]

(b) Find the acceleration. [1]

3.4 A 4 kg block rests on a 37° frictionless incline ($g = 10$ m s^{-2}).

(a) Find the component of gravity along the slope. [2]

(b) Find the block's acceleration down the slope. [1]

Solutions

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

2.2 $20 - 8 = 12$ N to the right.

2.3 The forces acting *on* the object.

2.4 $mg\sin\theta = 2(10)\sin 30° = 10$ N.

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

3.2 **B** — all forces acting on the object.

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

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