AP PHYSICS 1 • EXERCISE SHEET

2.2 Forces and Free-Body Diagrams

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

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

Objective

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

You must be able to:

- describe a **force** 力 as a push or pull, measured in **newtons** 牛顿
- distinguish **contact forces** 接触力 (normal, friction) from **long-range forces** 长程力 (gravity)
- draw a **free-body diagram** 受力图 showing every force on one object as a labelled arrow
- find the **net force** 合力 by adding the force vectors

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ What goes on a free-body diagram

Only the forces acting **on** the chosen object: weight (mg, down), normal force (F_N, perpendicular to the surface), friction (f, along the surface), tension (T, along a rope), and any applied push. Never draw a "motion" arrow.

■ Net force

Add the force components. A box pulled +10 N to the right against 4 N of friction: $F_{net} = 10 - 4 = 6$ N to the right.

■ Types of force

Contact: normal, friction, tension, applied push. **Long-range (field):** gravity (and, later, electric and magnetic).

2 Practice

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

2.2 State whether each is a contact or a long-range force: (a) weight, (b) friction, (c) normal force, (d) the gravitational pull of the Moon. [2]

2.3 A crate is pushed to the right with 25 N while 9.0 N of friction acts. Find the net horizontal force. [1]

2.4 A lamp of weight 15 N hangs in equilibrium from a single cord. State the tension in the cord. [1]

3 Exam-style questions

3.1 Which force is a long-range (field) force? [1]

- **A** the normal force
- **B** friction
- **C** gravity
- **D** tension

3.2 On a free-body diagram of a sliding box, which arrow should **not** appear? [1]

- **A** weight
- **B** normal force
- **C** friction
- **D** the box's velocity

3.3 A 2.0 kg sign hangs at rest from two vertical cords, each with tension T (take $g = 10\ \text{m s}^{-2}$).

(a) List the forces on the sign (a free-body diagram in words). [1]

(b) Find the tension in each cord. [2]

Solutions

2.1 weight, acting downward; and the normal force from the table, acting upward.

2.2 (a) long-range; (b) contact; (c) contact; (d) long-range.

2.3 $25 - 9.0 = 16$ N to the right.

2.4 15 N (equal to the weight, since it is in equilibrium).

3.1 **C**.

3.2 **D**.

3.3 (a) weight mg downward; two tension forces T upward. (b) $2T = mg = 20$ N, so $T = 10$ N.