

## 2.7 Kinetic and Static Friction

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 12 marks

### Objective

Build the skills to answer exam questions on **kinetic and static friction**.

**You must be able to:**

- distinguish **static friction** 静摩擦 (prevents sliding) from **kinetic friction** 动摩擦 (opposes sliding)
- use  $f_s \leq \mu_s F_N$  for maximum static friction and  $f_k = \mu_k F_N$  for kinetic friction
- explain that friction depends on the **normal force** 法向力 and the **coefficient of friction** 摩擦系数, not on contact area
- analyse the role of friction in motion and equilibrium

### 1 Worked examples

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

#### ■ Static friction adjusts itself

Static friction matches the applied force up to a maximum  $f_{s,\max} = \mu_s F_N$ . Below that, the object stays put; push harder than  $f_{s,\max}$  and it starts to slide.

#### ■ Kinetic friction is fixed

Once sliding,  $f_k = \mu_k F_N$  (usually  $\mu_k < \mu_s$ ). A 10 kg box on a floor,  $\mu_k = 0.30$ ,  $g = 10$ :  $F_N = 100$  N, so  $f_k = 0.30 \times 100 = 30$  N.

#### ■ Area doesn't matter

Friction depends on  $F_N$  and the surfaces, **not** on the contact area —a brick slides with the same friction on its large or small face.

### 2 Practice

**2.1** State the difference between static and kinetic friction.

[2]

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**2.2** A 5.0 kg block rests on a floor,  $\mu_k = 0.40$  (take  $g = 10$  m s<sup>-2</sup>). Find the kinetic

friction force once it slides. [2]

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**2.3** A box needs 18 N to start moving but only 12 N to keep moving. State which coefficient is larger,  $\mu_s$  or  $\mu_k$ . [1]

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**2.4** State what happens to the friction force if the same box is turned to rest on a smaller face. [1]

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### 3 Exam-style questions

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**3.1** The maximum static friction force is given by [1]

- **A**  $\mu_s F_N$
  - **B**  $\mu_k F_N$
  - **C**  $\mu_s mg \sin \theta$
  - **D**  $F_N / \mu_s$
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**3.2** Doubling the contact area (same weight) changes the kinetic friction force by a factor of [1]

- **A** 0.5
  - **B** 1 (no change)
  - **C** 2
  - **D** 4
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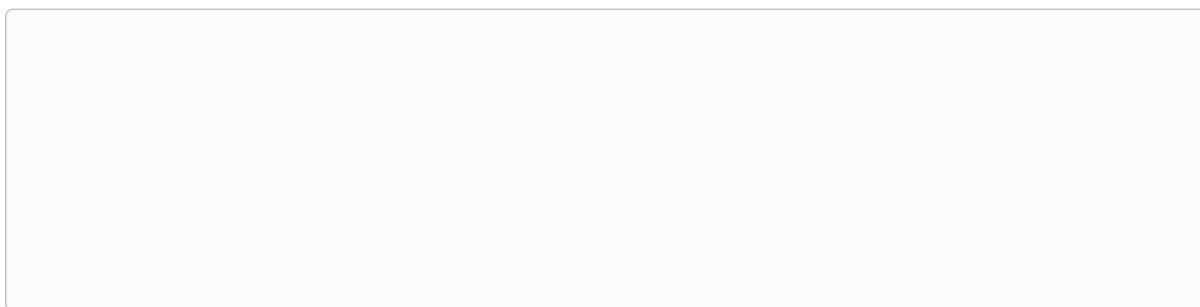
**3.3** A 4.0 kg block sits on a level floor,  $\mu_s = 0.50$ ,  $\mu_k = 0.30$  (take  $g = 10 \text{ m s}^{-2}$ ).

(a) Find the maximum static friction. [2]

(b) A horizontal push of 15 N is applied. State whether the block moves, and find the

friction force acting.

[2]



#### 4 Go further

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- work through the **2.7 Kinetic and Static Friction** lesson on the **Learn** page;
- read the **Force and Translational Dynamics** section of the AP Physics 1 handout on the **Know** page.

## Solutions

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**2.1** Static friction acts on a surface that is **not sliding** and adjusts up to a maximum; kinetic friction acts on a **sliding** surface and has a fixed value  $\mu_k F_N$ .

**2.2**  $F_N = mg = 50 \text{ N}$ ;  $f_k = 0.40 \times 50 = 20 \text{ N}$ .

**2.3**  $\mu_s$  is larger (more force is needed to start it moving).

**2.4** it is unchanged —friction does not depend on contact area.

**3.1 A.**

**3.2 B.**

**3.3** (a)  $F_N = 40 \text{ N}$ ,  $f_{s,\text{max}} = 0.50 \times 40 = 20 \text{ N}$ . (b)  $15 < 20 \text{ N}$ , so it does not move; static friction =  $15 \text{ N}$ , matching the push.