Exercise walk-through

Kinetic and Static Friction ▪ 2.7

eXercise

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

Method — 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.

Method — 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.

Method — 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.

Practice 2.1 ▪ 2 marks

State the difference between static and kinetic friction.

Solution 2.1

Worked steps

Static friction acts on a surface that is **not sliding** and adjusts up to a maximum B1; kinetic friction acts on a **sliding** surface and has a fixed value $\mu_k F_N$ B1.

Practice 2.2 ▪ 2 marks

A 5.0 kg block rests on a floor, $\mu_k = 0.40$ (take $g = 10$ m s^{-2}). Find the kinetic friction force once it slides.

Solution 2.2

Method: Kinetic friction is fixed

Worked steps

$F_N = mg = 50$ N (M1); $f_k = 0.40 \times 50 = 20$ N (A1).

Practice 2.3 ▪ 1 mark

A box needs 18 N to start moving but only 12 N to keep moving. State which coefficient is larger, μ_s or μ_k.

Solution 2.3

Worked steps

μ_s is larger (more force is needed to start it moving) B1.

Practice 2.4 ▪ 1 mark

State what happens to the friction force if the same box is turned to rest on a smaller face.

Solution 2.4

Method: Area doesn't matter

Worked steps

it is unchanged — friction does not depend on contact area B1.

Exam-style 3.1 ▪ 1 mark

The maximum static friction force is given by

A $\mu_s F_N$

B $\mu_k F_N$

C $\mu_s mg \sin\theta$

D F_N/μ_s

Solution 3.1

Method: Static friction adjusts itself

A $\mu_s F_N$ ✓

B $\mu_k F_N$

C $\mu_s mg \sin\theta$

D F_N/μ_s

Worked steps

A.

Exam-style 3.2 ▪ 1 mark

Doubling the contact area (same weight) changes the kinetic friction force by a factor of

A 0.5

B 1 (no change)

C 2

D 4

Solution 3.2

Method: Area doesn't matter

A 0.5

B 1 (no change) ✓

C 2

D 4

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A 4.0 kg block sits on a level floor, $\mu_s = 0.50$, $\mu_k = 0.30$ (take $g = 10$ m s^{-2}).
(a) Find the maximum static friction.
(b) A horizontal push of 15 N is applied. State whether the block moves, and find the friction force acting.

Solution 3.3

Method: Static friction adjusts itself

Worked steps

(a) $F_N = 40$ N, $f_{s,\max} = 0.50 \times 40 = 20$ N M1 A1. (b) $15 < 20$ N, so it does not move; static friction $= 15$ N, matching the push M1 A1.