Exercise walk-through

Kinetic and Static Friction ▪ 2.7

eXercise

You must be able to

- use **kinetic friction 动摩擦**: $f_k = \mu_k N$
- use the **static friction 静摩擦** limit: $f_s \leq \mu_s N$
- explain that static friction adjusts up to a maximum before slipping
- find the normal force N first, then the friction

Method — Kinetic friction

Once sliding, $f_k = \mu_k N$. A 10 kg block on the flat ($N = mg = 100$ N) with $\mu_k = 0.3$ feels

$$f_k = 0.3 \times 100 = 30 \text{ N},$$

opposing its motion.

Method — Static friction adjusts

Before sliding, static friction matches the applied force up to a maximum $f_{s,\max} = \mu_s N$. Push with 20 N on a block whose $f_{s,\max} = 40$ N and it does not move – static friction is exactly 20 N.

Method — Find the normal force first

On a flat surface $N = mg$; on an incline $N = mg\cos\theta$. Always find N, then multiply by μ.

Practice 2.1 ▪ 2 marks

A block with $N = 50$ N slides with $\mu_k = 0.2$. Find the kinetic friction.

Solution 2.1

Method: Kinetic friction

Worked steps

$f_k = \mu_k N = 0.2 \times 50 = 10$ N **M1** **A1**.

Practice 2.2 ▪ 1 mark

State the direction of the friction force on a sliding block.

Solution 2.2

Method: Static friction adjusts

Worked steps

Opposite to the motion B1.

Practice 2.3 ▪ 1 mark

A block has $f_{s,\max} = 30$ N. You push with 25 N and it stays still. State the static friction force.

Solution 2.3

Method: Static friction adjusts

Worked steps

25 N (static friction matches the applied force) B1.

Practice 2.4 ▪ 2 marks

A 4 kg block on the flat has $\mu_k = 0.25$ ($g = 10$ m s^{-2}). Find the kinetic friction while it slides.

Solution 2.4

Method: Kinetic friction

Worked steps

$N = mg = 40$ N; $f_k = 0.25 \times 40 = 10$ N M1 A1.

Exam-style 3.1 ▪ 1 mark

Kinetic friction on a sliding object is given by

A $\mu_k N$

B μ_k / N

C N / μ_k

D $\mu_k m$

Solution 3.1

Method: Kinetic friction

A $\mu_k N$ ✓

B μ_k / N

C N / μ_k

D $\mu_k m$

Worked steps

A — $f_k = \mu_k N$.

Exam-style 3.2 ▪ 1 mark

Static friction

A is always at its maximum

B adjusts up to a maximum, then the object slips

C is always larger than kinetic friction while sliding

D points in the direction of motion

Solution 3.2

Method: Static friction adjusts

A is always at its maximum

B adjusts up to a maximum, then the object slips ✓

C is always larger than kinetic friction while sliding

D points in the direction of motion

Worked steps

B — static friction adjusts up to a maximum, then slipping begins.

Exam-style 3.3 ▪ 2 marks

A 6 kg box on the flat has $\mu_s = 0.5$ and $\mu_k = 0.4$ ($g = 10$ m s^{-2}).
(a) Find the maximum static friction.
(b) Find the kinetic friction once it slides.

Solution 3.3

Method: Kinetic friction

Worked steps

(a) $N = 60$ N, $f_{s,\max} = 0.5 \times 60 = 30$ N **M1** **A1**. (b) $f_k = 0.4 \times 60 = 24$ N **B1**.

Exam-style 3.4 ▪ 2 marks

A 5 kg block is pushed along the flat by 30 N with $\mu_k = 0.2$ ($g = 10$ m s^{-2}).
(a) Find the kinetic friction.
(b) Find the net force and the acceleration.

Solution 3.4

Method: Kinetic friction

Worked steps

(a) $N = 50$ N, $f_k = 0.2 \times 50 = 10$ N M1 A1. (b) $F_{net} = 30 - 10 = 20$ N; $a = 20/5 = 4$ m s^{-2} M1 A1.