

Exercise walk-through

2.7

Kinetic and Static Friction

AP Physics C: Mechanics

2.7 Kinetic and Static Friction

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

KEY WORDS kinetic • static • normal force • friction • force

Objective

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

You must be able to:

- use **kinetic friction** : $F_{f,k} = \mu_k F_N$
- use the **static friction** limit: $F_{f,s} \leq \mu_s F_N$
- explain that static friction adjusts up to a maximum before slipping
- find the normal force F_N first, then the friction

1 Key knowledge and 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.

■ Kinetic friction

Once sliding, $F_{f,k} = \mu_k F_N$. A 10 kg block on the flat ($F_N = mg = 100$ N) with $\mu_k = 0.3$ feels

$$F_{f,k} = 0.3 \times 100 = 30 \text{ N},$$

opposing its motion.

■ Static friction adjusts

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

■ Find the normal force first

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

Exercises 2.1-2.3

2.1 A block with $F_N = 50$ N slides with $\mu_k = 0.2$. Find the kinetic friction. [2]

2.2 State the direction of the friction force on a sliding block. [1]

2.3 A block has $F_{f,s,\max} = 30$ N. You push with 25 N and it stays still. State the static friction force. [1]

Exercises 2.1-2.3

2.1 A block with $F_N = 50$ N slides with $\mu_k = 0.2$. Find the kinetic friction. [2]

2.1

- $F_{f,k} = \mu_k F_N = 0.2 \times 50 = 10$ N
-

2.2 State the direction of the friction force on a sliding block. [1]

2.2

- Opposite to the motion
-

2.3 A block has $F_{f,s,\max} = 30$ N. You push with 25 N and it stays still. State the static friction force. [1]

2.3

- 25 N (static friction matches the applied force)

Exercises 2.4-3.1

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

3.1 Kinetic friction on a sliding object is given by [1]

☐

A $\mu_k F_N$

B μ_k / F_N

C F_N / μ_k

D $\mu_k m$

Exercises 2.4·3.1

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

2.4

- $F_N = mg = 40 \text{ N}$; $F_{f,k} = 0.25 \times 40 = 10 \text{ N}$

3.1 Kinetic friction on a sliding object is given by [1]

- ☐ **A** $\mu_k F_N$
B μ_k / F_N
C F_N / μ_k
D $\mu_k m$

3.1 A

- $F_{f,k} = \mu_k F_N$

Exercise 3.2

3.2 Static friction

[1]

☐

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

Exercise 3.2

3.2 Static friction

[1]

☐

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

3.2 B

- static friction adjusts up to a maximum, then slipping begins

Exercise 3.3 (a)

3.3 A 6 kg box on the flat has $\mu_s = 0.5$ and $\mu_k = 0.4$ ($g = 10 \text{ m s}^{-2}$).

(a) Find the maximum static friction.

[2]

Exercise 3.3 (a)

3.3 A 6 kg box on the flat has $\mu_s = 0.5$ and $\mu_k = 0.4$ ($g = 10 \text{ m s}^{-2}$).

(a) Find the maximum static friction.

[2]

(a)

- $F_N = 60 \text{ N}$, $F_{f,s,\max} = 0.5 \times 60 = 30 \text{ N}$

Exercise 3.3 (b)

3.3 A 6 kg box on the flat has $\mu_s = 0.5$ and $\mu_k = 0.4$ ($g = 10 \text{ m s}^{-2}$).

(b) Find the kinetic friction once it slides.

[1]

Exercise 3.3 (b)

3.3 A 6 kg box on the flat has $\mu_s = 0.5$ and $\mu_k = 0.4$ ($g = 10 \text{ m s}^{-2}$).

(b) Find the kinetic friction once it slides.

[1]

(b)

- $F_{f,k} = 0.4 \times 60 = 24 \text{ N}$

Exercise 3.4 (a)

3.4 A 5 kg block is pushed along the flat by 30 N with $\mu_k = 0.2$ ($g = 10 \text{ m s}^{-2}$).

(a) Find the kinetic friction.

[2]

Exercise 3.4 (a)

3.4 A 5 kg block is pushed along the flat by 30 N with $\mu_k = 0.2$ ($g = 10 \text{ m s}^{-2}$).

(a) Find the kinetic friction.

[2]

(a)

- $F_N = 50 \text{ N}$, $F_{f,k} = 0.2 \times 50 = 10 \text{ N}$

Exercise 3.4 (b)

3.4 A 5 kg block is pushed along the flat by 30 N with $\mu_k = 0.2$ ($g = 10 \text{ m s}^{-2}$).

(b) Find the net force and the acceleration.

[2]

Exercise 3.4 (b)

3.4 A 5 kg block is pushed along the flat by 30 N with $\mu_k = 0.2$ ($g = 10 \text{ m s}^{-2}$).

(b) Find the net force and the acceleration.

[2]

(b)

- $F_{net} = 30 - 10 = 20 \text{ N}$; $a = 20/5 = 4 \text{ m s}^{-2}$