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.

2 Practice

Now apply the methods above.

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]

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

3 Exam-style questions

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** $\mu_k m$

3.2 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

3.3 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. [2]

(b) Find the kinetic friction once it slides. [1]

3.4 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. [2]

(b) Find the net force and the acceleration. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

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

2.2

- Opposite to the motion

2.3

- 25 N (static friction matches the applied force)

2.4

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

3.1 A

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

3.2 B

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

3.3

(a)

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

(b)

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

3.4

(a)

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

(b)

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