2 Friction, springs, and circular motion – Part 2

Name: ____________ Class: ________ Date: __________

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
normal force	法向力			
Friction	摩擦力			
Static friction	静摩擦			
Kinetic friction	动摩擦			
coefficient of friction	摩擦系数			
Hooke's law	胡克定律			
spring constant	弹簧常数			
centripetal acceleration	向心加速度			
centripetal force	向心力			

Recall

In Part A you drew free-body diagrams and used $\sum F = ma$. Now meet three everyday forces that appear again and again:

- **Friction** slows sliding –you feel it when you drag a heavy box.
- A **spring** pulls back when you stretch it.
- Anything moving in a **circle** needs a force pulling it inward.

Each idea below has a worked example before the Practice.

New ideas

■ 1 The normal force

When an object rests on a surface, the surface pushes back at right angles to it. This is the **normal force** 法向力 N. On a flat floor it balances the weight, so $N = mg$.

Worked example. A 5.0 kg box on a level floor has $N = mg = 5.0 \times 9.8 = 49$ N.

■ 2 Friction

Friction 摩擦力 acts along a surface and opposes sliding. It comes in two kinds:

- **Static friction** 静摩擦 (before sliding) adjusts itself up to a maximum $f_s \leq \mu_s N$ to stop motion starting.
- **Kinetic friction** 动摩擦 (while sliding) is $f_k = \mu_k N$.

Here μ is the **coefficient of friction** 摩擦系数 (a number for how rough the contact is).

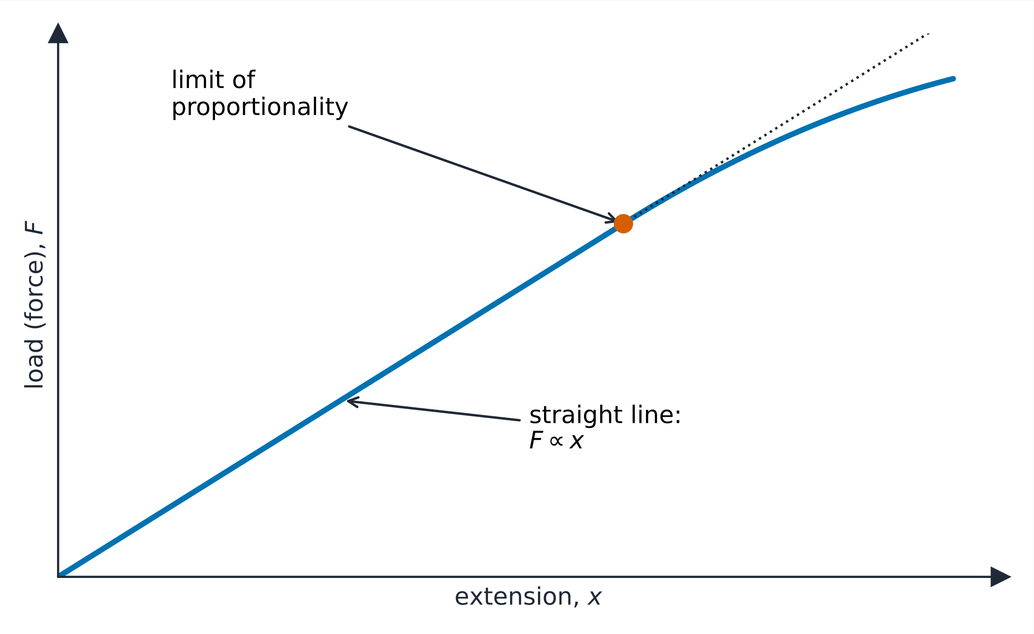
Worked example. A crate with $N = 49$ N and $\mu_s = 0.40$ needs a push above $f_{s,\max} = \mu_s N = 0.40 \times 49 = 19.6$ N to start moving. A 15 N push is too small, so it stays still.

■ 3 Springs and Hooke's law

A spring pulls (or pushes) back toward its natural length. **Hooke's law** 胡克定律 says the force is proportional to the stretch x:

$$F_s = kx,$$

where k is the **spring constant** 弹簧常数 (its stiffness).

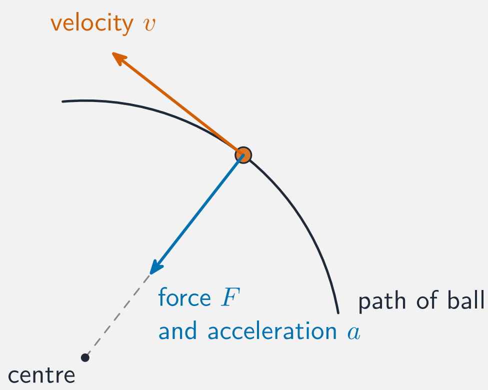


Worked example. A spring with $k = 200$ N/m holds a 0.50 kg mass at rest. The spring force balances the weight, $kx = mg$, so $x = \dfrac{mg}{k} = \dfrac{0.50 \times 9.8}{200} = 0.025$ m $= 2.5$ cm.

■ **4 Circular motion**

An object moving in a circle at steady speed is still **accelerating**, because its direction keeps changing. This **centripetal acceleration** 向心加速度 points to the centre:

$$a_c = \frac{v^2}{r}.$$



It is caused by a real inward **centripetal force** 向心力 $F_c = \dfrac{mv^2}{r}$ –supplied by tension, gravity, or friction.

Watch out: there is no outward ”centrifugal” force pulling you out of the circle. The only force is the real one pulling you **inward**; you feel pushed out only because your body wants to keep going straight.

Practice

Try these in order. The methods are all above.

2.1 A 4.0 kg block sits on a flat floor. Find the normal force on it ($g = 9.8$ m/s^2). [2]

2.2 Using that block, the coefficient of static friction is $\mu_s = 0.30$. Find the largest static friction force before it slides. [2]

2.3 A spring stretches 0.040 m when a 12 N force pulls it. Find the spring constant k. [2]

2.4 Explain why an object going around a circle at constant speed is still accelerating. [2]

2.5 A 0.30 kg ball is whirled in a circle of radius 0.80 m at 4.0 m/s. Find the centripetal force needed. [3]

2.6 A student says a car turning a corner is pushed **outward** by a force. Correct this statement. [2]