13 Newton's law of gravitation – 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)		
Newton's law of gravitation	万有引力定律			
universal gravitational constant	万有引力常量			
point mass	质点			

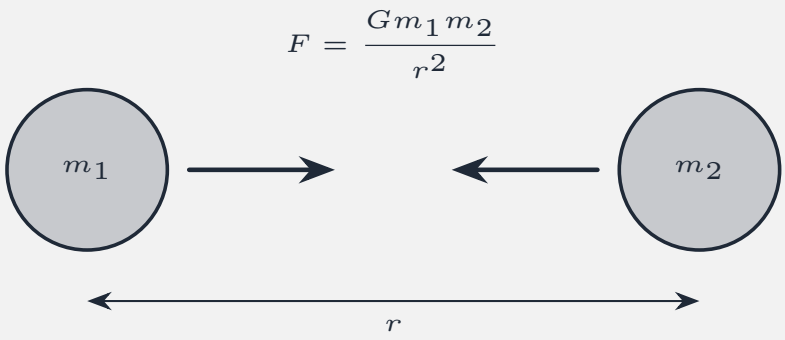
Recall

Any two masses attract each other. Newton's law tells us how strongly —the same law that explains the orbits of planets and the pull of the Moon on the tides.

New ideas

Read these first. Each idea has a short worked example. Then do the Practice.

> ■ **1 Newton's law of gravitation**



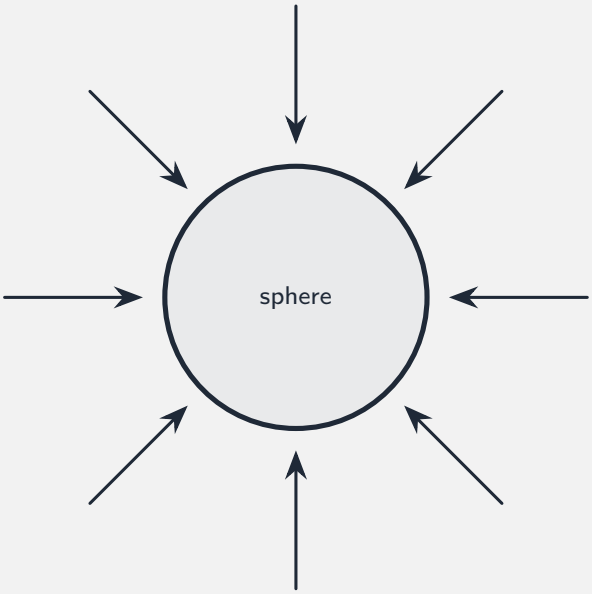
Newton's law of gravitation 万有引力定律: two point masses attract with force

$$F = \frac{Gm_1m_2}{r^2},$$

where $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} is the **universal gravitational constant** 万有引力常量. The force is along the line joining them.

Worked example. Two 2000 kg masses sit 1.0 m apart: $F = \frac{Gm_1m_2}{r^2} = \frac{(6.67 \times 10^{-11})(2000)(2000)}{1.0^2} = 2.7 \times 10^{-4}$ N —tiny, because G is so small.

■ 2 Spheres act like point masses



From outside, a uniform sphere (like a planet) acts like a **point mass** 质点 with all its mass at the centre. So the field strength at its surface is $g = GM/r^2$.

Worked example. For the Earth ($M = 6.0 \times 10^{24}$ kg, $r = 6.4 \times 10^{6}$ m): $g = \dfrac{GM}{r^2} = \dfrac{(6.67 \times 10^{-11})(6.0 \times 10^{24})}{(6.4 \times 10^{6})^2} \approx 9.8$ N kg^{-1} —exactly the value we measure.

Watch out: the force follows an *inverse-square* law, so if r doubles the force falls to a *quarter*, not a half.

Practice

Try these in order.

13.1 Write *Newton's law of gravitation.* [1]

13.2 If the distance r doubles, what happens to the force? [1]

13.3 What does G stand for? [1]

13.4 Two 3000 kg masses are 2.0 m apart. Find the gravitational force between them

($G = 6.67 \times 10^{-11}$). [2]

13.5 From outside, what can a uniform sphere be treated as? [1]

13.6 Explain why we clearly feel the Earth's gravity, but not a noticeable pull towards a nearby mountain. [2]

13.7 Challenge. Planet X has twice the Earth's mass and twice the Earth's radius. Using $g = GM/r^2$, find how its surface gravity compares with the Earth's. [2]