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			

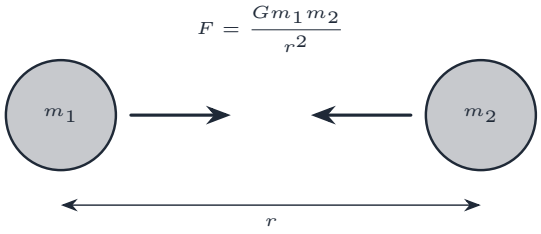
Recall

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



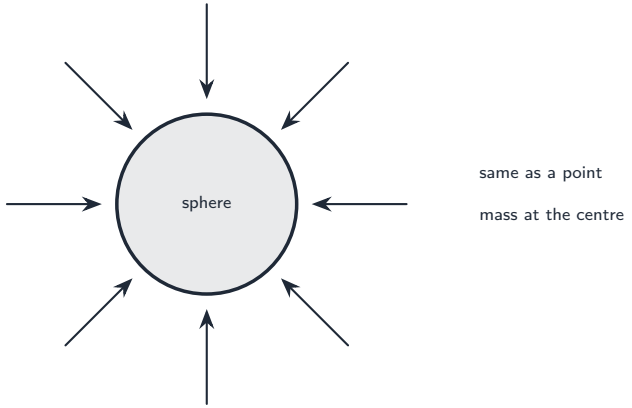
Newton's law of gravitation 万有引力定律: two point masses attract with force

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

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]