

13.2 Gravitational force between point masses

Name: _____ Class: _____ Date: _____

Total: 16 marks

KEY WORDS orbit 轨道 • period 周期 • satellite 卫星 • centripetal force 向心力
• geostationary 地球同步

Objective

Build the skills to answer exam questions on **Newton's law of gravitation** and orbits.

You must be able to:

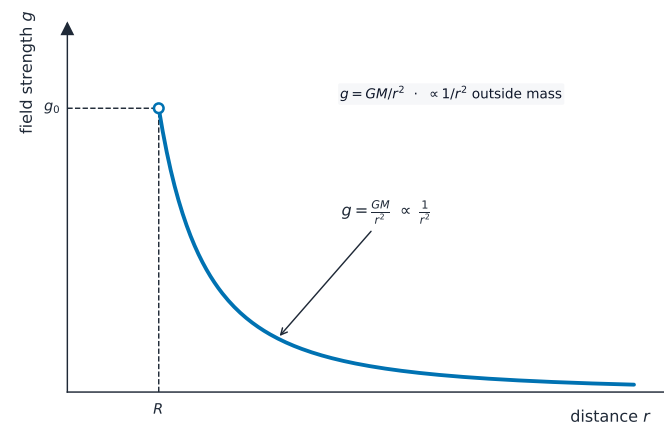
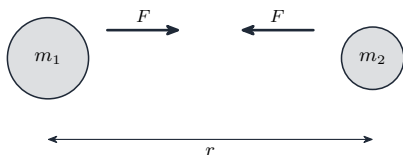
- use $F = \frac{Gm_1m_2}{r^2}$ and treat a sphere as a point mass
- analyse **circular orbits** (gravity provides the centripetal force)
- describe a **geostationary orbit**

1 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.

■ Newton's law of gravitation

Two point masses attract with **equal, opposite** forces along the line joining them:



Gravitational field strength against distance

$$F = \frac{Gm_1m_2}{r^2}, \quad G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}.$$

A uniform sphere acts as a **point mass at its centre** for points outside it.

■ Circular orbits

For a satellite, gravity **is** the centripetal force:

$$\frac{GMm}{r^2} = \frac{mv^2}{r} = mr\omega^2 \Rightarrow T^2 = \frac{4\pi^2 r^3}{GM}.$$

A **geostationary** satellite: period **24 h**, orbits **west→east** above the **equator**, staying over one point on Earth.

2 Practice

Now apply the methods above.

2.1 State Newton's law of gravitation.

[2]

2.2 State the value and unit of the gravitational constant G .

[1]

2.3 Two 1000 kg masses are 2.0 m apart. Find the gravitational force between them. [2]

2.4 State **two** features of a **geostationary** orbit. [2]

3 Exam-style questions

3.1 If the distance between two masses is **doubled**, the gravitational force becomes: [1]

- | | |
|---|---|
| A | B |
| C | D |
- A twice as large
B half as large
C one quarter as large
D four times as large

3.2 Calculate the gravitational field strength at the Earth's surface. ($M = 6.0 \times 10^{24}$ kg, $R = 6.4 \times 10^6$ m, $G = 6.67 \times 10^{-11}$.) [3]

3.3 A satellite moves in a circular orbit of radius r around a planet of mass M . Show that gravity provides the centripetal force, and derive an expression linking the orbital **period** T to r . [4]

3.4 State why a **geostationary** satellite must orbit directly above the **equator**. [1]