

16.1 Gravitational fields and orbital motion

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS gravitational field • centripetal force

Objective

Gravitational fields and orbital motion. Original classroom practice for IB HL; not an official IB paper.

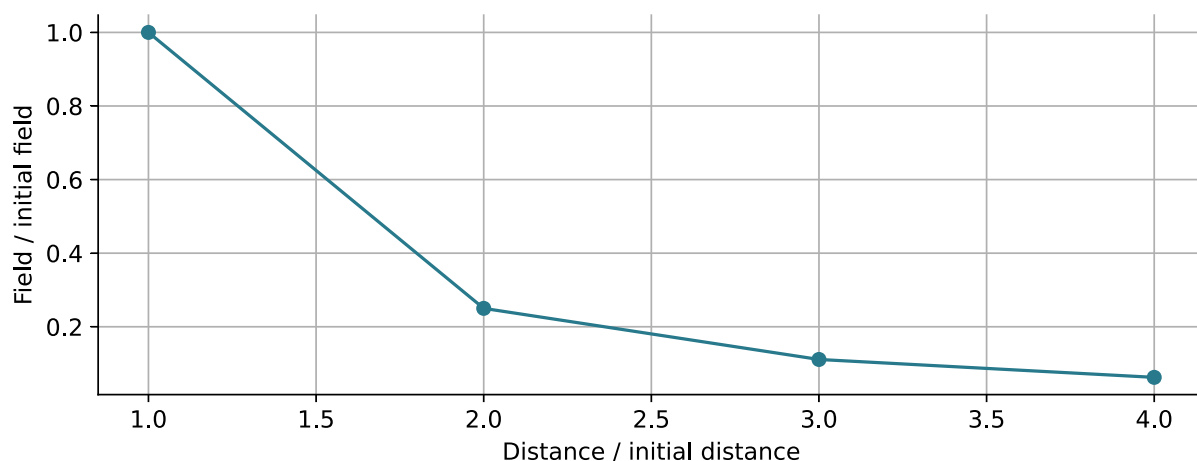
1 Key knowledge and worked examples

■ What would explain this observation?

- An orbiting satellite is continuously falling while moving sideways. Being in orbit does not require gravity to vanish.

■ Build the model

- **Gravitational field** strength is force per unit mass.
- A gravitational force can provide the **centripetal force** for a circular orbit.
- Field and potential describe different quantities.
- gravitational field: A description of gravitational force per unit mass.
- centripetal force: Net force toward the centre of a curved path.



■ Choose evidence that can test it

- For a point mass or outside a spherical mass, field strength follows an inverse-square distance dependence.
- Use distance from the centre, not height above the surface alone.

In the lab: State the circular-orbit approximation and ignore atmospheric drag only when justified. Draw the force toward the central body and velocity tangential to the orbit. Do not add an outward force merely because the path is circular.

■ Work from known quantities

- Known: field strength is 8 units at distance r from a spherical source.
- At $2r$, $g_2/g_1 = (r/2r)^2 = 1/4$. $g_2 = 8/4 = 2$ units.
- The gravitational force on a fixed test mass decreases in the same ratio.

Your turn: Field strength is 18 units at r . Find it at $3r$ for an inverse-square field.

■ Check the conclusion and its limits

- Weightlessness in an orbiting spacecraft means apparent weight is small in free fall, not that there is no gravitational field.

Not true: Gravity is zero everywhere a spacecraft experiences apparent weightlessness. An orbiting spacecraft is in free fall: gravity is nearly as strong there as on the ground and supplies the centripetal force. Crew and craft fall together, so nothing presses them down - that is apparent weightlessness, not zero gravity.

Key:

- Gravitational field strength is force per unit mass.
- For a point mass or outside a spherical mass, field strength follows an inverse-square distance dependence.
- Watch for: weightlessness in an orbiting spacecraft means apparent weight is small in free fall, not that there is no gravitational field.

■ Write from a field strength of 8 units

- An inverse-square field has strength 72 units at distance r .
- Find the strength at $3r$. Apparent weightlessness in orbit is not zero gravity.

2 Practice

2.1 What direction is the net force in uniform circular motion? Choose one answer.

- **A** Toward the centre
- **B** Always outward
- **C** Along the velocity

[1]

2.2 Field strength is 18 units at r . Find it at $3r$ for an inverse-square field. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: An orbiting spacecraft is in free fall: gravity is nearly as strong there as on the ground and supplies the centripetal force. [2]

2.4 A description of gravitational force per unit mass: write the technical term. [1]

3 Exam-style questions

3.1 A spherical source produces field 12 units at r . At $2r$ the test mass is doubled. Compare field and force with the original case. [4]
