A-LEVEL PHYSICS • EXERCISE SHEET

13.1 Gravitational field

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

KEY WORDS gravitational field 重力场 • field line 场线 • gravitational field strength 重力场强度 • force 力 • mass 质量

Objective

Build the skills to answer exam questions on the **gravitational field** — its definition and field lines.

You must be able to:

- define **gravitational field strength** as force per unit mass
- represent a gravitational field with **field lines**

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.

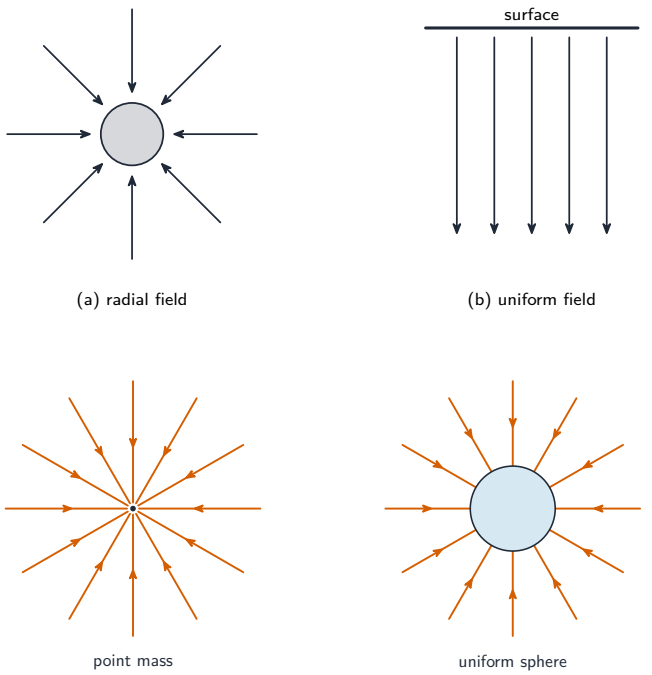
■ Field strength

A **gravitational field** is a region where a mass feels a force. The **field strength** is the force per unit mass on a small test mass:

$$g = \frac{F}{m} \quad (\text{N kg}^{-1}).$$

It is a **vector**, pointing towards the source mass (the same value as the free-fall acceleration).

■ Field lines



The radial gravitational field of a sphere

- around a **point mass / sphere**: **radial**, pointing **inwards**;
- near a surface (small region): **uniform** — parallel, equally spaced, pointing down.

Closer lines → stronger field.

2 Practice

Now apply the methods above.

2.1 Define **gravitational field strength**. [1]

2.2 State the unit of gravitational field strength. [1]

2.3 State what a gravitational **field line** represents. [1]

2.4 State the shape of the gravitational field around a **point mass**. [1]

3 Exam-style questions

3.1 Gravitational field strength is equal to: [1]

A | B
C | D

A force × mass
B force ÷ mass
C mass ÷ force
D mass × acceleration

3.2 A mass of 2.0 kg experiences a gravitational force of 19.6 N. Find the **gravitational field strength**. [2]

3.3 Explain what **closer** field lines indicate. [1]

3.4 Sketch the gravitational field lines (a) around a point mass and (b) near a flat surface. [2]

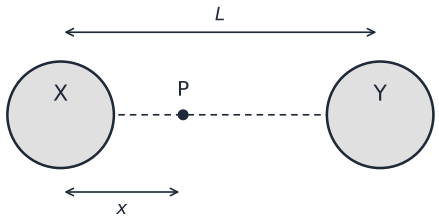
3.5 A point mass M sits at the origin. Point P is a distance x from it.

(a) **Define** the **gravitational field** at a point. [1]

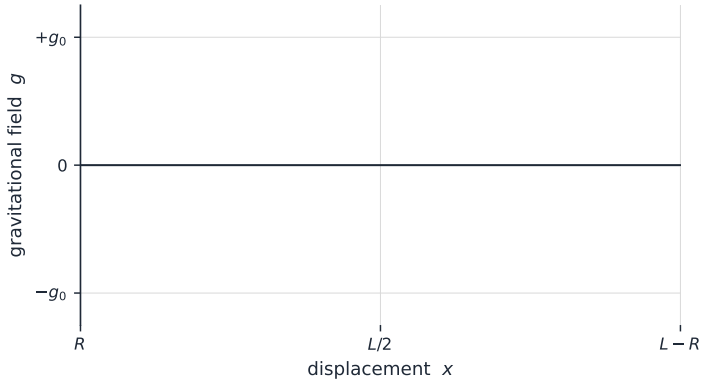
(b) By considering the force on a test mass m placed at P, **derive** an expression for the gravitational field strength g at P in terms of M and x. State the meaning of any other symbol you use. [2]

(c) Point Q lies on the **opposite** side of the mass from P, at a distance $\frac{x}{2}$ from it. **Compare** the gravitational field at Q with the field at P. [2]

(d) Two identical uniform spheres X and Y, each of radius R, have their centres a distance L apart. Point P now lies on the line joining their centres, a displacement x from the centre of X. The gravitational field strength at the surface of each sphere is g_0.



On the axes below, **sketch** how the field g at P varies with x, from $x = R$ to $x = L - R$. Take the direction from X towards Y as positive. [3]



(e) **Explain** why the field is zero at the midpoint, even though neither sphere has been removed. [2]