Edexcel Physics A-level

Topic 12: Gravitational Fields

Key Points

Gravitational Fields

A force field is a region in which a body experiences a **non-contact** force.

Gravitational fields are regions where objects with mass experience an **attractive force** due to gravity. This force is determined by **Newton's Law of Gravitation**, which states that:

- The force is **directly** proportional to product of the **masses** involved
- The force is **inversely** proportional to the square of the **separation** between the two masses

As an equation this is:

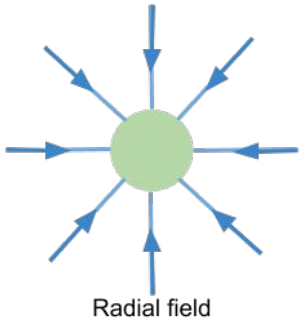
$$F = \frac{GMm}{r^2}$$

(G = Gravitational Constant)

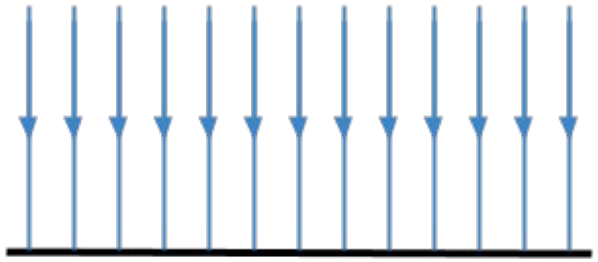
Field Lines

Field lines can be drawn to represent a gravitational field. The lines:

- Always point towards the **centre** of the mass producing the field
- Show the **direction** in which a mass would experience a force if placed at a point in that field
- Are **closer** together at points where the field is **stronger**
- Are **further** apart at points where the field is **weaker**
- **Never cross** over each other



Radial field



Uniform field

Gravitational Field Strength

A useful way to compare gravitational fields is by comparing gravitational field strengths. Gravitational field strength is defined as the **attractive gravitational force** that a **unit mass** would experience, at a **given point** in the field. As an equation this is:

$$g = \frac{F}{m}$$

Which for a radial field gives...

$$g = \frac{GM}{r^2}$$

The gravitational field strength at the **surface of Earth** is roughly **9.81 N/kg**. This means that a mass of 1kg would experience of force of 9.81N.

Gravitational Potential

Gravitational potential at a point is the amount of **work done** in moving a **unit mass** from **infinity** to that **point** in a gravitational field. As an equation this is:

$$V = \frac{-GM}{r}$$

The key points to note are that:

- Gravitational potential is defined as being **zero at infinity**
- **Work is done** to move an object closer to the centre of the field, and so gravitational potential is always a **negative value**

Equipotentials are planes containing points with equal gravitational potential. This means that the amount of work done when an object is moved around these planes is **zero**.

Orbits

The orbits of planets and satellites are a result of the **gravitational force** produced by the body they are orbiting. This force acts as a **centripetal force**, which results in circular motion. There are many different types of orbit, and you should know that:

- **Synchronous orbits** have a time period of one day, and so return to the same place in the sky each day.
- **Low orbits** orbit at heights of between 160 km and 2000 km.
- **Geostationary orbits** have a time period of one day and stay over the same point on the Earth's surface. They must be directly above the equator and travel in the same direction as the earth's rotation.

Comparing Gravitational and Electrical Fields

Similarities

Gravitational Fields	Electric Fields
Gravitational field strength (g) is force per unit mass.	Electric field strength (E) is force per unit +ve charge.
Newton's Law of gravitation for force between 2 masses is an inverse square law.	Coulomb's Law for electric force between 2 +ve point charges is an inverse square law.
The field lines around a point mass show the force acting on a point mass.	The field lines around a point charge show the force acting on a positive point charge.
Gravitational potential (V_{grav}) is the potential energy per unit mass, and is 0 at infinity.	Electric potential (V) is the potential energy per unit positive charge, and is 0 at infinity.

Differences

Gravitational Fields	Electric Fields
Forces are always attractive.	Forces can be attractive or repulsive.
Objects cannot be shielded from the field.	Objects *can* be shielded from the field.
The size of the force *doesn't* depend on the medium between masses.	The size of the force *does* depend on the medium between charges.