OCR (A) A-Level Physics

5.4 Gravitational Fields

Flashcards

What is gravity?

What is gravity?

Gravity is the universal attractive force which acts between all matter.

What is *G*?

What is G?

The universal gravitational constant.

Approx. 6.67×10^{-11} m^3 kg^{-1} s^{-2}

What can field lines tell you about a field?

What can field lines tell you about a field?

The direction of the field and the strength of the field depending on the density of the field lines.

What is g?

What is g?

- g is the force per unit area in a uniform gravitational field.
- In a radial field the magnitude of g is the the proportionality constant at that point between force and mass.
- I.e. $g = GM/r^2$

What is Newton's law of Gravitation?

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Newton's law of gravitation states that two point masses attract each other with a force that is directly proportional to the product of their masses, and inversely proportional to the square of the distance between them.

What is Kepler's first law?

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Kepler's first law states that *the orbit of a planet is an ellipse, with the sun at one focus.* The eccentricity of the ellipse is very low, so the motion can be modelled as circular.

What is Kepler's second law?

What is Kepler's second law?

Kepler's second law states that *a line segment joining a planet and the sun sweeps out equal areas during intervals of equal time.* This is because the speed of the planet is not constant – the planet moves faster when it is closer to the sun.

What is Kepler's third law?

Kepler's third law states that *the square of the orbital period T is proportional to the cube of the average distance r from the sun.* This can be proved by considering the forces acting on the planet. Centripetal force is required to keep the planet in orbit, and this force is provided by the gravitational field of the sun.

Derive this equation to show T^2 is proportional to r^3 and explain your steps

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

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1. Because of Kepler's third law, we can equate the formula for centripetal force with the formula for gravitational force to get **$mv^2/r = GMm/r^2$**

2. Rearrange to get **$v^2 = GM/r$**

3. Since velocity in circular motion is **$2\pi r/T$**, you can substitute this into the previous equation to get **$4\pi^2 r^2/T^2 = GM/r$**

4. Rearrange this to get **$T^2 = 4\pi^2 r^3 / GM$**

What are satellites? What are they used for?

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- Satellites are objects that orbit other, larger objects. These can include natural satellites like the moon, and artificial satellites that humans have sent into space.

- Uses include: communications, scientific research, and Global Positioning Systems (GPS).

What are geostationary satellites? What are they used for?

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- Geostationary satellites have an orbital period that is exactly a day, so that they appear stationary above the Earth.

- They orbit 36,000km above the equator.

- They are useful for communications and surveying as they provide continuous coverage.

What is gravitational potential?

What is gravitational potential?

The potential energy per kilogram, at any point in the field.
0 potential is defined at infinity, so at a point close to a mass, the potential of an object would be negative.

What is gravitational potential difference?

What is gravitational potential difference?

Gravitational potential difference is the difference in the gravitational potentials of two points in a gravitational field.

What is gravitational potential energy at a point in the field?

What is gravitational potential energy at a point in the field?

The work done per unit mass in moving object with from infinity to that point in the field.

What is escape velocity?

What is escape velocity?

- The minimum velocity an object requires in order to escape the gravitational field of an object when projected vertically from its surface.
- The formula for v_{esc} is derived from equating the kinetic energy and the gravitational potential energy required to reach infinity: $\frac{1}{2} mv^2 = GMm/r$
  - Rearrange this to get $v_{esc} = \sqrt{2GM/r}$