Physics 20

Unit B: Forces and gravitation

Universal gravitation

Two lead spheres on a bench

- A 20.0 kg sphere and a 5.00 kg sphere, centres 0.150 m apart, attract each other.
- The same pattern of attraction reaches from an apple to Earth and from Earth to the Moon.

A fundamental attraction and its constant

- Gravity pulls every pair of masses toward each other.
- F is the pull, G is the gravity constant, m1 and m2 are the masses, and r is the centre to centre distance.
- Universal gravitation writes F = G m1 m2 / r squared, and G equals 6.67e-11 N m squared per kg squared.

Key terms

gravitational force

Gravitational force is the attractive force between two masses, directed along the line that joins their centres. (F)

universal gravitation

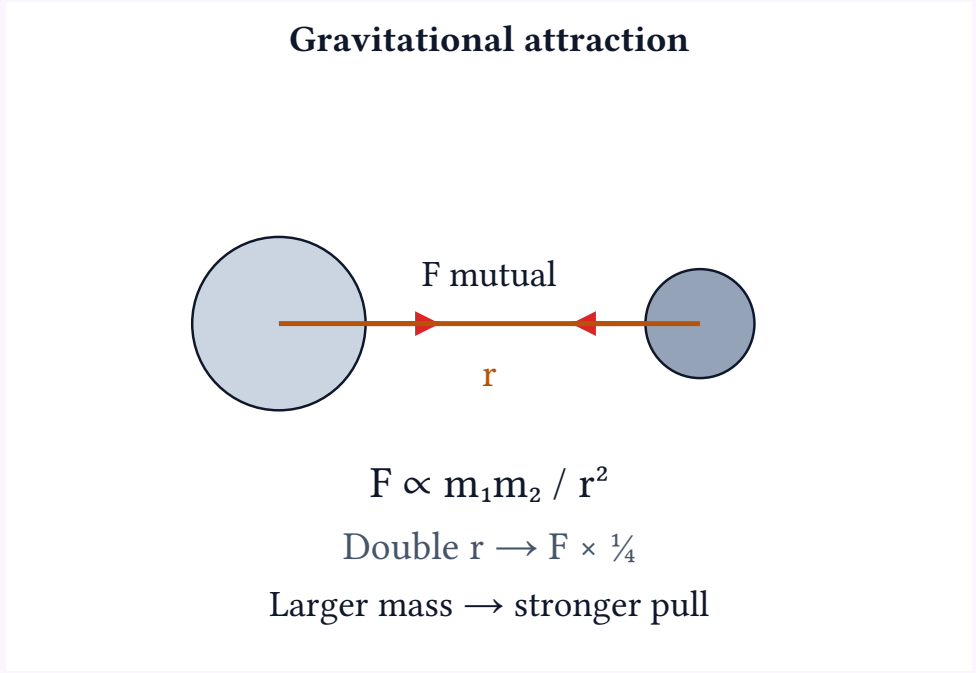
Universal gravitation is the law that every pair of masses attracts with F = G m1 m2 / r squared. ($F = G\ m1\ m2 / r^2$)

gravitational constant

The gravitational constant G is 6.67e-11 N m squared per kg squared, the number that sets the strength of the attraction. (G)

Masses strengthen it, distance weakens it

- A larger mass on either side increases the gravitational force.
- Doubling the centre to centre distance multiplies the force by one quarter.
- The attraction is mutual and lies on the line of centres.



The bench sphere calculation

- F = (6.67e-11)(20.0)(5.00) / (0.150 m)².
- G is 6.67e-11 N m squared per kg squared.
- The gravitational force magnitude is 2.96e-7 N.

A fibre that measured G

- Cavendish used a torsion balance with small masses on a suspended rod.
- Large masses attract the small masses and the torsion fibre twists.
- The twist measures the gravitational force and therefore measures G.



Equal 10.0 kg spheres

- Two 10.0 kg spheres have centres 0.200 m apart.
- Compute r squared first.
- Find the gravitational force magnitude.

A new pair

- Masses of 4.00 kg and 9.00 kg have centres 0.300 m apart.
- Find the gravitational force magnitude.
- State what a torsion fibre twist measured in Cavendish’s experiment.

Image credits

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