LESSON MAKER PRO

Forces Across Space

Use G = 6.67 x 10⁻¹¹ N m²/kg² and k = 9 x 10⁹ N m²/C².

HIGH SCHOOL · HS-PS2-4

HS-PS2-4 "Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects..."

NAME _____ DATE _____

FORCES AND FIELDS

For objects separated by distance r, gravitational force is $F_g = Gm_1m_2/r^2$, and electric force magnitude is $F_e = k|q_1q_2|/r^2$. Gravity attracts, while like charges repel and opposite charges attract. Field strength is force per unit mass, $g = F_g/m$, or force per unit positive charge, $E = F_e/q$.

WORKED EXAMPLE

Two objects have masses of 3 kg and 12 kg. Their centers are 6 m apart. Find the gravitational force between them.

1. Use $F_g = Gm_1m_2/r^2$.
2. Substitute: $F_g = (6.67 \times 10^{-11})(3)(12)/(6^2)$.
3. Simplify: $(3)(12)/6^2 = 36/36 = 1$.

Answer: 6.67×10^{-11} N, attractive

PRACTICE 6 problems

1 Two 5 kg objects are 5 m apart. Find the gravitational force between them.

ANSWER _____

2 A 10 kg object and a 20 kg object are 10 m apart. Find the gravitational force between them.

ANSWER _____

3 A 5 kg probe is 5 m from a 25 kg object. Find the gravitational field strength at the probe and state its direction.

ANSWER _____

4 Charges of $+1 \times 10^{-6}$ C and -1×10^{-6} C are 1 m apart. Find the electric force magnitude and state whether the charges attract or repel.

ANSWER _____

5 Two charges of $+5 \times 10^{-6}$ C are 5 m apart. Find the electric force magnitude and state whether the charges attract or repel.

ANSWER _____

6 Find the electric field strength 1 m from a charge of $+1 \times 10^{-6}$ C. State the field's direction.

ANSWER _____

APPLY IT Show your work

1 Two student-built satellites, each with a mass of 100 kg, are 10 m apart in space. Find the gravitational force they exert on each other and state its direction.

WORK SPACE

ANSWER _____

2 At a school event, two balloons each have a charge of $+1 \times 10^{-9}$ C. Their centers are 0.1 m apart. Find the electric force between them and state whether they attract or repel.

WORK SPACE

ANSWER _____

CHALLENGE One step up

A charge of $+1 \times 10^{-6}$ C creates an electric field. Find the field strength at a point 1 m away and at a point 5 m away. How many times stronger is the field at 1 m? Explain using distance.

WORK SPACE AND ANSWER

Forces Across Space

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Two 5 kg objects are 5 m apart. Find the gravitational force between them.	**6.67×10^{-11} N**
2	A 10 kg object and a 20 kg object are 10 m apart. Find the gravitational force between them.	**1.334×10^{-10} N**
3	A 5 kg probe is 5 m from a 25 kg object. Find the gravitational field strength at the probe and state its direction.	**6.67×10^{-11} N/kg, toward the 25 kg object**
4	Charges of $+1 \times 10^{-6}$ C and -1×10^{-6} C are 1 m apart. Find the electric force magnitude and state whether the charges attract or repel.	**9×10^{-3} N, attractive**
5	Two charges of $+5 \times 10^{-6}$ C are 5 m apart. Find the electric force magnitude and state whether the charges attract or repel.	**9×10^{-3} N, repulsive**
6	Find the electric field strength 1 m from a charge of $+1 \times 10^{-6}$ C. State the field's direction.	**9×10^{3} N/C, away from the positive charge**

PART 2 · APPLY IT

1. **6.67×10^{-9} N, toward each other** $F_g = (6.67 \times 10^{-11})(100)(100)/10^2 = 6.67 \times 10^{-9}$ N. Gravity attracts.
2. **9×10^{-7} N, repulsive** $F_e = (9 \times 10^{9})(1 \times 10^{-9})(1 \times 10^{-9})/(0.1)^2 = 9 \times 10^{-7}$ N. Like charges repel.

CHALLENGE

At 1 m, $E = 9 \times 10^3$ N/C. At 5 m, E = 360 N/C. The field is 25 times stronger at 1 m because field strength is inversely proportional to distance squared, and $5^2 = 25$.

Accept equivalent scientific notation or decimal forms with correct units. For field directions, accept wording that clearly points toward a mass or away from a positive charge.