



Show equations, substitutions, units, and vector directions. Explain your reasoning. Use sensible rounding.

Constants	$e = 1.60 \times 10^{-19} \text{ C}$ $k = 9.0 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$ $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$ $1 \mu\text{C} = 10^{-6} \text{ C}$ $1 \text{ nC} = 10^{-9} \text{ C}$
Equations	$ q = Ne$ $F_e = k q_1q_2 /r^2$ $E = F/ q $ $ F_e = q E$ $F_g = Gm_1m_2/r^2$ $g = F_g/m = GM/r^2$ $v_{\text{orbit}} = \sqrt{GM/r}$

Use center-to-center distance. Orbital-speed equation applies to circular orbits.

6.1 Electric Charge

1. An object gains 2.0×10^{12} electrons. Find its net charge. A different object has charge $+4.8 \times 10^{-9} \text{ C}$. How many electrons did it lose?

2. Two identical conducting spheres initially carry $+8.0 \text{ nC}$ and -2.0 nC . They touch, then separate. Find each final charge. Explain the difference between charging by contact and polarization without contact.

6.2 Coulomb's Law

3. Charges $+2.0 \mu\text{C}$ and $-5.0 \mu\text{C}$ are 0.30 m apart. Find the electric-force magnitude and state whether the force is attractive or repulsive. Compare the forces on the two charges.

4. The force between two charges is F . Find the new force in terms of F if (a) distance doubles, (b) both charge magnitudes double, and (c) one charge doubles while distance triples.

6.3 Electric Fields

5. Draw electric field lines for (a) one positive charge, (b) one negative charge, and (c) a positive-negative pair. Show arrow directions and identify where closer line spacing indicates stronger field.



6. A $+3.0 \mu\text{C}$ test charge experiences 0.060 N east. Find the electric field. What force would act on an electron placed at the same point?

6.4 Universal Gravitation

7. Two spherical masses of 1000 kg and 2000 kg have centers 5.0 m apart. Find the gravitational-force magnitude on each.

8. A satellite moves from distance R to distance $3R$ from a planet's center. How does the gravitational force change? If its altitude is $2R$ above a planet of radius R , what distance belongs in the gravity equation?

6.5 Gravitational Fields and Orbits

9. A planet has mass 6.0×10^{24} kg and radius 6.0×10^6 m. Calculate gravitational field strength at the surface and at an altitude equal to one planet radius.
10. A satellite has a circular orbit of radius 8.0×10^6 m around a planet of mass 6.0×10^{24} kg. Find orbital speed. Explain why orbiting astronauts can feel weightless even when gravity is substantial.

6.6 Comparing Gravity and Electric Forces

11. Complete the comparison table. Use mass, charge, attraction, repulsion, and inverse-square behavior in your responses.
- | Property | Gravitational force | Electric force |
|-------------------|---------------------|----------------|
| Source property | | |
| Attract or repel? | | |
| Dependence on r | | |
12. For an electron-proton pair, the electric force is 8.2×10^{-8} N and gravity is 3.6×10^{-47} N. Calculate their ratio. Explain why gravity can still dominate planetary motion.

Unit 6 Review

13. A charge in a uniform field of $5.0 \times 10^3 \text{ N/C}$ upward experiences a force of 0.020 N downward. Find the charge, including its sign.
14. Two identical positive charges, each $+3.0 \mu\text{C}$, repel with a force of 0.90 N . Find the distance between them.
15. Two equal positive charges sit at equal distances left and right of point P. Find the net electric field direction at P. Would your answer remain true if the right-hand charge doubled? Explain.
16. Explain how pushing two positive charges closer together can store energy. How is this similar to lifting an object near Earth's surface?