Applied Physics

ES-111 Fall 2024

Assignment 5; Chapter 21-22

Deadline of submission: 24.12.2024

Q1. An average human weighs about 650 N. If each of two average humans could carry 1.0 C of excess charge, one positive and one negative, how far apart would they have to be for the electric attraction between them to equal their 650-N weight?

Q2. If a proton and an electron are released when they are 2.0 x 10^{-10} m apart (a typical atomic distance), find the initial acceleration of each particle.

Q3. Two small plastic spheres are given positive electric charges. When they are 15.0 cm apart, the repulsive force between them has magnitude 0.220 N. What is the charge on each sphere (a) if the two charges are equal and (b) if one sphere has four times the charge of the other?

Q4. Three-point charges are arranged on a line. Charge $q3$ = +5.00 nC and is at the origin. Charge $q2$ = -3.00 nC and is at x = +4.00 cm. Charge $q1$ is at x = +2.00 cm. What is $q1$ (magnitude and sign) if the net force on $q3$ is zero?

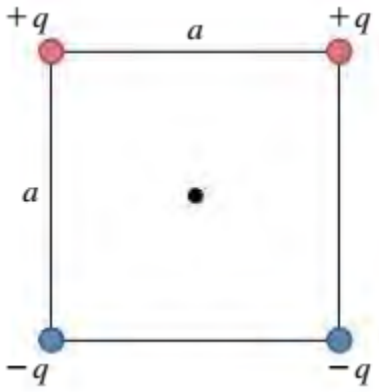
Q5. Two-point charges are placed on the x-axis as follows: Charge $q1$ = +4.00 nC is located at x = 0.200 m, and charge $q2$ = +5.00 nC is at x = -0.300 m. What are the magnitude and direction of the total force exerted by these two charges on a negative point charge $q3$ = -6.00 nC that is placed at the origin?

Q6. The earth has a net electric charge that causes a field at points near its surface equal to 150 N/C and directed in toward the center of the earth. (a) What magnitude and sign of charge would a 60-kg human have to acquire to overcome his or her weight by the force exerted by the earth's electric field? (b) What would be the force of repulsion between two people each with the charge calculated in part (a) and separated by a distance of 100 m? Is use of the earth's electric field a feasible means of flight? Why or why not?

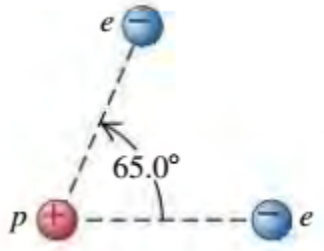
Q7. (a) What must the charge (sign and magnitude) of a 1.45-g particle be for it to remain stationary when placed in a downward-directed electric field of magnitude 650 N/C? (b) What is the magnitude of an electric field in which the electric force on a proton is equal in magnitude to its weight?

Q8. Two positive point charges q are placed on the x-axis, one at $x = a$ and one at $x = -a$. (a) Find the magnitude and direction of the electric field at $x = 0$. (b) Derive an expression for the electric field at points on the x-axis. Use your result to graph the x-component of the electric field as a function of x, for values of x between $-4a$ and $+4a$.

Q9. A point charge is placed at each corner of a square with side length a. All charges have magnitude q. Two of the charges are positive and two are negative (**Fig.**). What is the direction of the net electric field at the center of the square due to the four charges, and what is its magnitude in terms of q and a?



Q10. If two electrons are each $1.50 * 10^{-10}$m from a proton (**Fig.**), find the magnitude and direction of the net electric force they will exert on the proton.



Q11. Four identical charges Q are placed at the corners of a square of side L. (a) In a free-body diagram, show all of the forces that act on one of the charges. (b) Find the magnitude and direction of the total force exerted on one charge by the other three charges.

Q12. Three identical point charges q are placed at each of three corners of a square of side L. Find the magnitude and direction of the net force on a point charge $-3q$ placed (a) at the center of the square and (b) at the vacant corner of the square. In each case, draw a free-body diagram showing the forces exerted on the $-3q$ charge by each of the other three charges.

Q13. Negative charge $-Q$ is distributed uniformly around a quarter-circle of radius a that lies in the first quadrant, with the center of curvature at the origin. Find the x- and y-components of the net electric field at the origin.

Q14. A semicircle of radius *a* is in the first and second quadrants, with the center of curvature at the origin. Positive charge +*Q* is distributed uniformly around the left half of the semicircle, and negative charge -*Q* is distributed uniformly around the right half of the semicircle (**Fig.**). What are the magnitude and direction of the net electric field at the origin produced by this distribution of charge?

Q15. A hemispherical surface with radius *r* in a region of uniform electric field ***E*** has its axis aligned parallel to the direction of the field. Calculate the flux through the surface.

Q16. charged paint is spread in a very thin uniform layer over the surface of a plastic sphere of diameter 12.0 cm, giving it a charge of -49.0 mC. Find the electric field (a) just inside the paint layer; (b) just outside the paint layer; (c) 5.00 cm outside the surface of the paint layer.

Q17. A solid metal sphere with radius 0.450 m carries a net charge of 0.250 nC. Find the magnitude of the electric field (a) at a point 0.100 m outside the surface of the sphere and (b) at a point inside the sphere, 0.100 m below the surface.

Q18. (a) How many excess electrons must be distributed uniformly within the volume of an isolated plastic sphere 30.0 cm in diameter to produce an electric field of magnitude 1390 N/C just outside the surface of the sphere? (b) What is the electric field at a point 10.0 cm outside the surface of the sphere?

Q19. Negative charge -*Q* is distributed uniformly over the surface of a thin spherical insulating shell with radius *R*. Calculate the force (magnitude and direction) that the shell exerts on a positive point charge *q* located a distance (a) $r > R$ from the center of the shell (outside the shell); (b) $r < R$ from the center of the shell (inside the shell).

Q20. A point charge of -3.00 mC is located in the center of a spherical cavity of radius 6.50 cm that, in turn, is at the center of an insulating charged solid sphere. The charge density in the solid is $\rho = 7.35 * 10^{-4}$ C/m3. Calculate the electric field inside the solid at a distance of 9.50 cm from the center of the cavity.

Q21. A charge *q*1 = +5.00 nC is placed at the origin of an *xy*-coordinate system, and a charge *q*2 = -2.00 nC is placed on the positive *x*-axis at *x* = 4.00 cm. (a) If a third charge *q*3 = +6.00 nC is now placed at the point *x* = 4.00 cm, *y* = 3.00 cm, find the *x*- and *y*-components of the total force exerted on this charge by the other two. (b) Find the magnitude and direction of this force.

Q22. Negative charge -*Q* is distributed uniformly around a quarter-circle of radius *a* that lies in the first quadrant, with the center of curvature at the origin. Find the *x*- and *y*-components of the net electric field at the origin.

Q23. A charged paint is spread in a very thin uniform layer over the surface of a plastic sphere of diameter 12.0 cm, giving it a charge of -49.0 mC. Find the electric field (a) just inside the paint layer; (b) just outside the paint layer; (c) 5.00 cm outside the surface of the paint layer

Q24. How many excess electrons must be added to an isolated spherical conductor 26.0 cm in diameter to produce an electric field of magnitude 1150 N/C just outside the surface?

22.53 •• **CALC** A nonuniform, but spherically symmetric, distribution of charge has a charge density $\rho(r)$ given as follows:

$$\rho(r) = \rho_0\left(1 - \frac{r}{R}\right) \qquad \text{for } r \leq R$$

$$\rho(r) = 0 \qquad \text{for } r \geq R$$

where $\rho_0 = 3Q/\pi R^3$ is a positive constant. (a) Show that the total charge contained in the charge distribution is Q. (b) Show that the electric field in the region $r \geq R$ is identical to that produced by a point charge Q at $r = 0$. (c) Obtain an expression for the electric field in the region $r \leq R$. (d) Graph the electric-field magnitude E as a function of r. (e) Find the value of r at which the electric field is maximum, and find the value of that maximum field.