

Halliday ♦ Resnick ♦ Walker

FUNDAMENTALS OF PHYSICS
SIXTH EDITION

Selected Solutions

Chapter 24

24.15

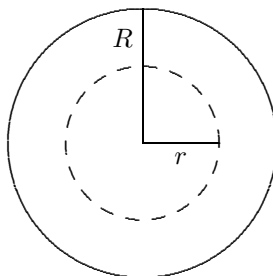
24.25

24.39

15. (a) Consider a Gaussian surface that is completely within the conductor and surrounds the cavity. Since the electric field is zero everywhere on the surface, the net charge it encloses is zero. The net charge is the sum of the charge q in the cavity and the charge q_w on the cavity wall, so $q + q_w = 0$ and $q_w = -q = -3.0 \times 10^{-6} \text{ C}$.
- (b) The net charge Q of the conductor is the sum of the charge on the cavity wall and the charge q_s on the outer surface of the conductor, so $Q = q_w + q_s$ and

$$q_s = Q - q_w = (10 \times 10^{-6} \text{ C}) - (-3.0 \times 10^{-6} \text{ C}) = +1.3 \times 10^{-5} \text{ C} .$$

25. (a) The diagram below shows a cross section (or, perhaps more appropriately, “end view”) of the charged cylinder (solid circle). Consider a Gaussian surface in the form of a cylinder with radius r and length ℓ , coaxial with the charged cylinder. An “end view” of the Gaussian surface is shown as a dotted circle. The charge enclosed by it is $q = \rho V = \pi r^2 \ell \rho$, where $V = \pi r^2 \ell$ is the volume of the cylinder.



If ρ is positive, the electric field lines are radially outward, normal to the Gaussian surface and distributed uniformly along it. Thus, the total flux through the Gaussian cylinder is $\Phi = EA_{\text{cylinder}} = E(2\pi r\ell)$. Now, Gauss' law leads to

$$2\pi\epsilon_0 r\ell E = \pi r^2 \ell \rho \implies E = \frac{\rho r}{2\epsilon_0} .$$

- (b) Next, we consider a cylindrical Gaussian surface of radius $r > R$. If the external field E_{ext} then the flux is $\Phi = 2\pi r\ell E_{\text{ext}}$. The charge enclosed is the total charge in a section of the charged cylinder with length ℓ . That is, $q = \pi R^2 \ell \rho$. In this case, Gauss' law yields

$$2\pi\epsilon_0 r\ell E_{\text{ext}} = \pi R^2 \ell \rho \implies E_{\text{ext}} = \frac{R^2 \rho}{2\epsilon_0 r} .$$

39. The proton is in uniform circular motion, with the electrical force of the sphere on the proton providing the centripetal force. According to Newton's second law, $F = mv^2/r$, where F is the magnitude of the force, v is the speed of the proton, and r is the radius of its orbit, essentially the same as the radius of the sphere. The magnitude of the force on the proton is $F = eq/4\pi\epsilon_0 r^2$, where q is the magnitude of the charge on the sphere. Thus,

$$\frac{1}{4\pi\epsilon_0} \frac{eq}{r^2} = \frac{mv^2}{r}$$

so

$$\begin{aligned} q &= \frac{4\pi\epsilon_0 mv^2 r}{e} = \frac{(1.67 \times 10^{-27} \text{ kg})(3.00 \times 10^5 \text{ m/s})^2 (0.0100 \text{ m})}{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)(1.60 \times 10^{-19} \text{ C})} \\ &= 1.04 \times 10^{-9} \text{ C} . \end{aligned}$$

The force must be inward, toward the center of the sphere, and since the proton is positively charged, the electric field must also be inward. The charge on the sphere is negative: $q = -1.04 \times 10^{-9} \text{ C}$.