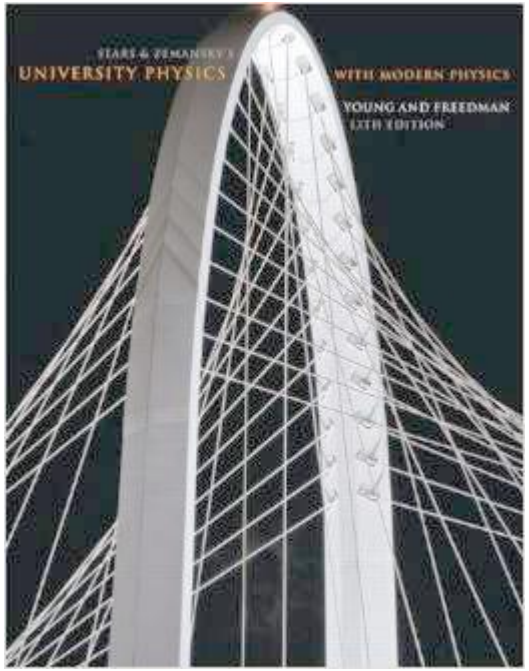
These Questions & their Solutions are taken From Our Reference Book



University Physics with Modern Physics

(13th Edition, 2012)

Authors :

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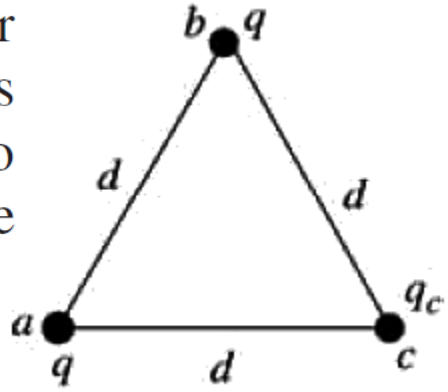
23.11 •• Three point charges, which initially are infinitely far apart, are placed at the corners of an equilateral triangle with sides d. Two of the point charges are identical and have charge q. If zero net work is required to place the three charges at the corners of the triangle, what must the value of the third charge be?



$$W = -\Delta U = -(U_2 - U_1),$$

Let q_c be the third, unknown charge.

$$U_1 = 0$$

$$U_2 = U_{ab} + U_{ac} + U_{bc} = \frac{1}{4\pi\epsilon_0 d}(q^2 + 2qq_c)$$

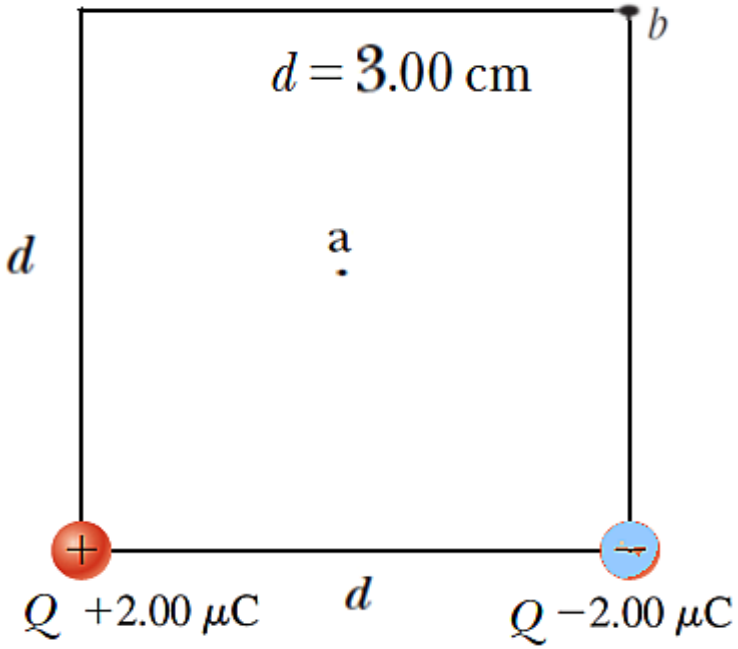
Want $W = 0$,

$W = -(U_2 - U_1)$ gives $0 = -U_2$

$$0 = \frac{1}{4\pi\epsilon_0 d}(q^2 + 2qq_c)$$

$q^2 + 2qq_c = 0$ and $q_c = -q/2$.

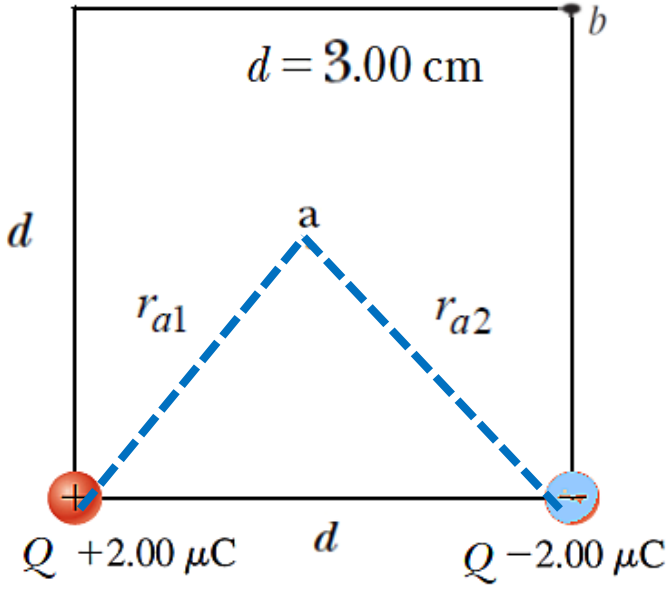
23.17 •• Point charges $q_1 = +2.00\ \mu C$ and $q_2 = -2.00\ \mu C$ are placed at adjacent corners of a square for which the length of each side is 3.00 cm. Point a is at the center of the square, and point b is at the empty corner closest to q_2. Take the electric potential to be zero at a distance far from both charges. (a) What is the electric potential at point a due to q_1 and q_2? (b) What is the electric potential at point b? (c) A point charge $q_3 = -5.00\ \mu C$ moves from point a to point b. How much work is done on q_3 by the electric forces exerted by q_1 and q_2? Is this work positive or negative?



(a)

$$r_{a1} = r_{a2} = \frac{1}{2}\sqrt{(0.0300\ \text{m})^2 + (0.0300\ \text{m})^2} = 0.0212\ \text{m}.$$

$$V_a = k\left(\frac{q_1}{r_{a1}} + \frac{q_2}{r_{a2}}\right) = 0.$$



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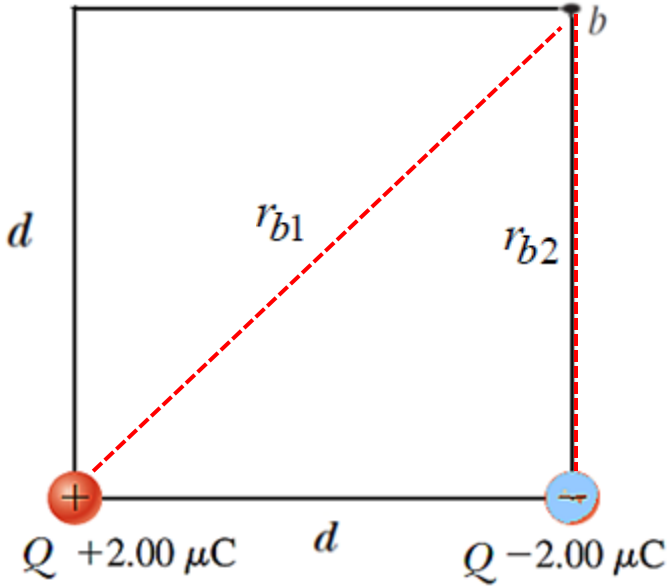


(b) $r_{b1} = 0.0424\ \text{m}, \quad r_{b2} = 0.0300\ \text{m}.$

$$V_b = k\left(\frac{q_1}{r_{b1}} + \frac{q_2}{r_{b2}}\right)$$

$$= (8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\left(\frac{+2.00\times10^{-6}\ \text{C}}{0.0424\ \text{m}} + \frac{-2.00\times10^{-6}\ \text{C}}{0.0300\ \text{m}}\right) = -1.75\times10^5\ \text{V}.$$

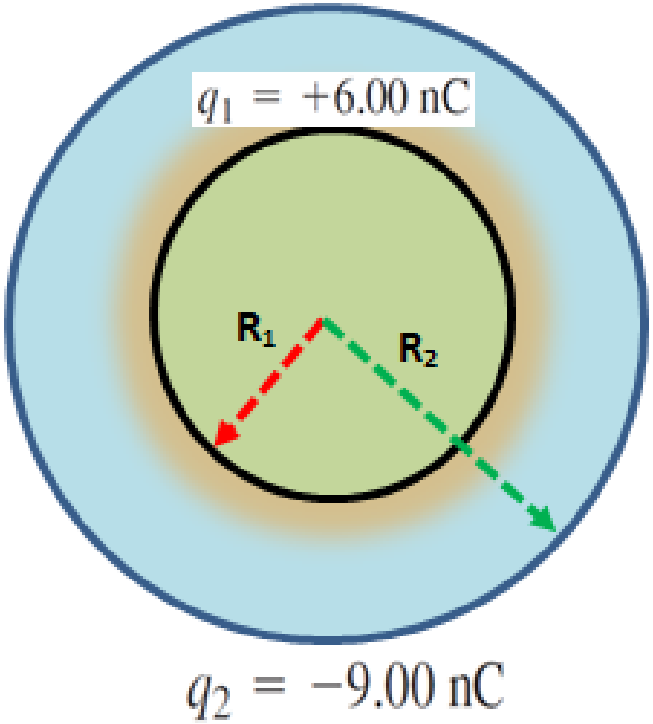
(c) $W_{ab} = q_3(V_a - V_b)$

$$= (-5.00\times10^{-6}\ \text{C})[0 - (-1.75\times10^5\ \text{V})] \quad = -0.875\ \text{J}.$$

23.27 •• A thin spherical shell with radius $R_1 = 3.00$ cm is concentric with a larger thin spherical shell with radius $R_2 = 5.00$ cm. Both shells are made of insulating material. The smaller shell has charge $q_1 = +6.00$ nC distributed uniformly over its surface, and the larger shell has charge $q_2 = -9.00$ nC distributed uniformly over its surface. Take the electric potential to be zero at an infinite distance from both shells. (a) What is the electric potential due to the two shells at the following distance from their common center: (i) $r = 0$; (ii) $r = 4.00$ cm; (iii) $r = 6.00$ cm? (b) What is the magnitude of the potential difference between the surfaces of the two shells? Which shell is at higher potential: the inner shell or the outer shell?

(a)

r=0cm



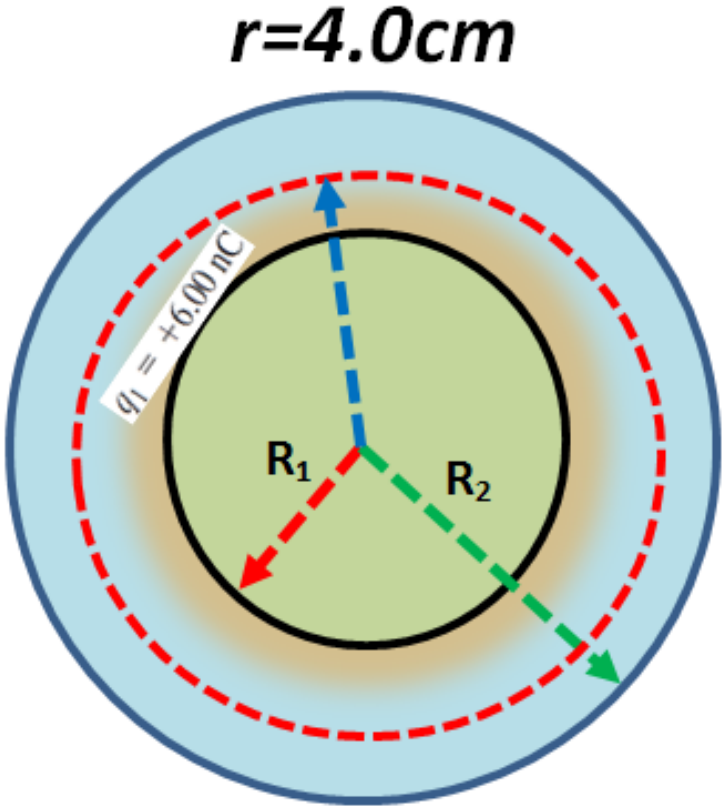
(i) $r = 0$

$$V = k\left(\frac{q_1}{R_1} + \frac{q_2}{R_2}\right)$$

$$= (8.99\times10^9\ \mathrm{N\cdot m^2/C^2})\left(\frac{6.00\times10^{-9}\ \mathrm{C}}{0.0300\ \mathrm{m}} + \frac{-9.00\times10^{-9}\ \mathrm{C}}{0.0500\ \mathrm{m}}\right)$$

$$V = +1.798\times10^3\ \mathrm{V} + (-1.618\times10^3\ \mathrm{V}) = 180\ \mathrm{V}.$$

(a)



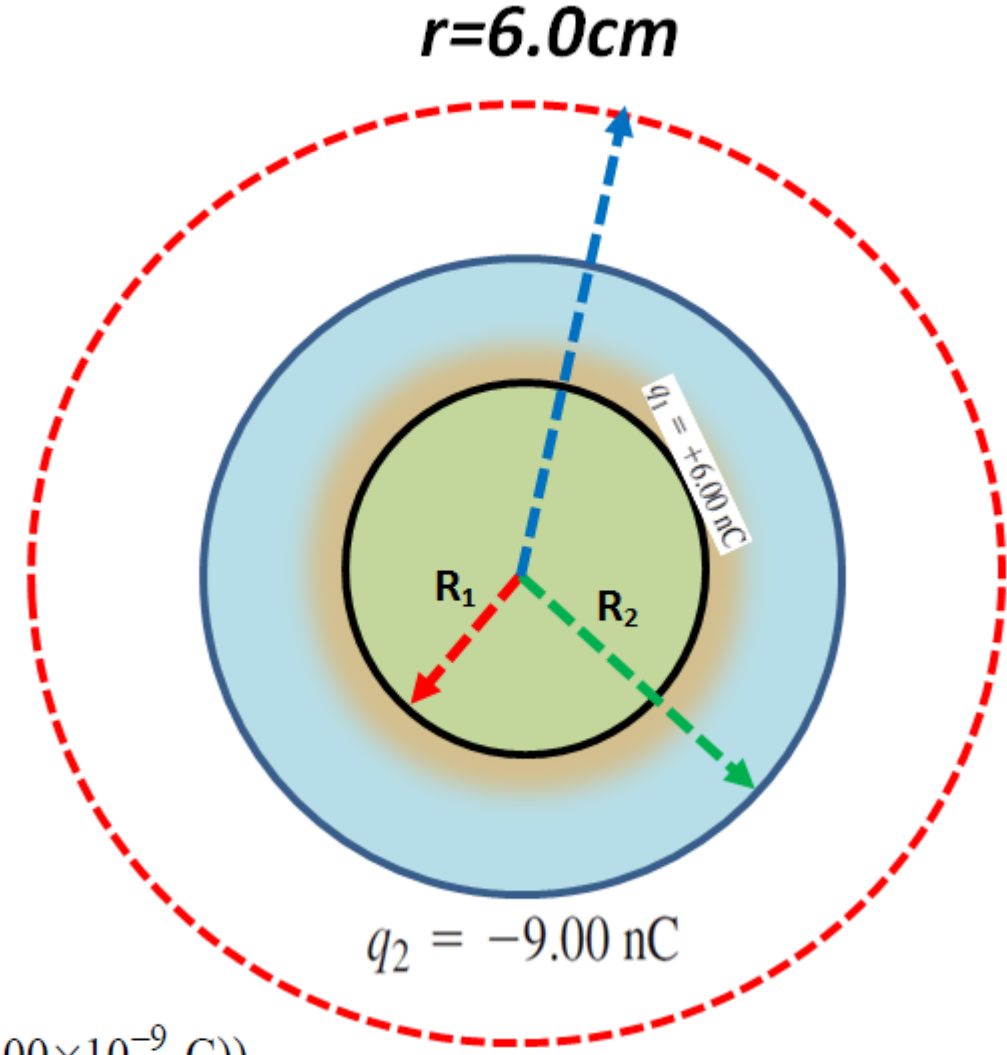
(ii) $r = 4.00$ cm

$$V = k\left(\frac{q_1}{r} + \frac{q_2}{R_2}\right)$$

$$= (8.99\times10^9\ \mathrm{N\cdot m^2/C^2})\left(\frac{6.00\times10^{-9}\ \mathrm{C}}{0.0400\ \mathrm{m}} + \frac{-9.00\times10^{-9}\ \mathrm{C}}{0.0500\ \mathrm{m}}\right)$$

$$V = +1.348\times10^3\ \mathrm{V} + (-1.618\times10^3\ \mathrm{V}) = -270\ \mathrm{V}.$$

(a)



(iii) $r = 6.00$ cm.

$$V = k\left(\frac{q_1}{r} + \frac{q_2}{r}\right)$$

$$= \frac{k}{r}(q_1 + q_2)$$

$$= \frac{8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2}{0.0600\ \text{m}}(6.00\times10^{-9}\ \text{C} + (-9.00\times10^{-9}\ \text{C})).$$

$$V = -450\ \text{V}.$$

(b) At the surface of the inner shell, $r = R_1 = 3.00$ cm

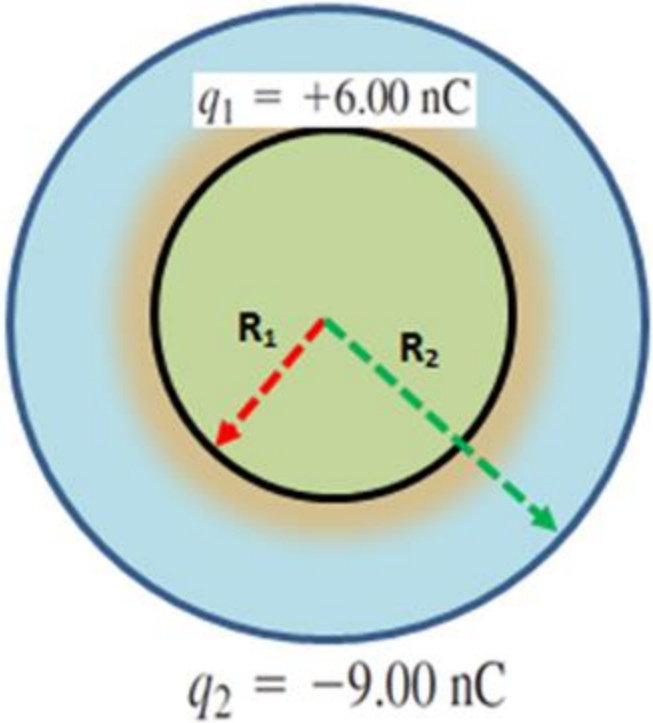
$$V_1 = k\left(\frac{q_1}{R_1} + \frac{q_2}{R_2}\right) = 180 \text{ V}$$

At the surface of the outer shell, $r = R_2 = 5.00$ cm

$$V = k\left(\frac{q_1}{r} + \frac{q_2}{R_2}\right)$$

$$= (8.99\times10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)\left(\frac{6.00\times10^{-9} \text{ C}}{0.0500 \text{ m}} + \frac{-9.00\times10^{-9} \text{ C}}{0.0500 \text{ m}}\right)$$

$$V_2 = +1.079\times10^3 \text{ V} + (-1.618\times10^3 \text{ V}) = -539 \text{ V}$$



The potential difference is $V_1 - V_2 = 719$ V

The inner shell is at higher potential.

The potential difference is due entirely to the charge on the inner shell.