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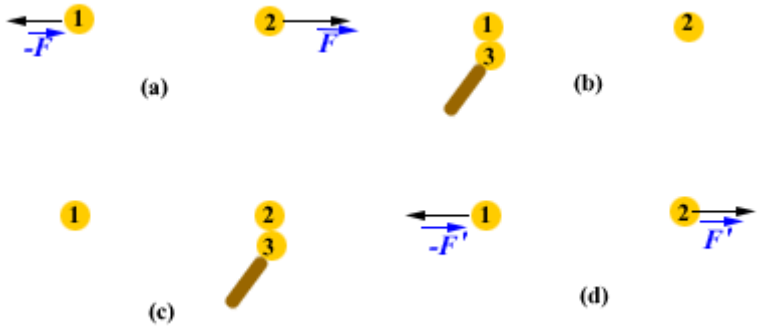
Problem 22.7E (HRW)

Identical isolated spheres 1 *and* 2 *have equal amounts of charge and are separated by a distance large compared with their diameters. The electrostatic force on sphere* 2 *due to sphere* 1 *is* $\vec{F}$ (fig.a). *Suppose now that a third identical sphere* 3, *having an insulating handle and initially neutral, is touched first to sphere 1* (fig.b) *and then to sphere* 2 (fig.c), *and finally removed. In terms of* $\vec{F}$, *we have to find the force* $\vec{F}'$ (fig.d) *that now acts on sphere* 2.



Solution:

Let initially the equal charge on identical conducting spheres 1 and 2 be *q*. By Coulomb's law the magnitude of force F on 2 due to 1, if the separation *d* between the

two charges which is assumed to be much greater than their size, will be

$$F = \frac{1}{4\pi\varepsilon_0} \times \frac{q^2}{d^2}.$$

When the identical conducting sphere 3 which is electrically neutral and is held by an insulating handle is touched with conducting sphere 1, charge of amount $q/2$ will be passed on to sphere 3 from sphere 1. Now the conducting sphere 3 which has charge $q/2$ on it is brought in contact with sphere 2 having charge q, the total charge of amount $q + \frac{q}{2}$ will be equally divided between conducting spheres 2 and 3. The charge on conducting sphere 2 will therefore be $3q/4$.

Therefore, the magnitude of force on sphere 2 due to conducting sphere 1 by Coulomb's law will be

$$F' = \frac{1}{4\pi\varepsilon_0} \times \frac{\left(\frac{q}{2}\right) \times \left(\frac{3q}{4}\right)}{d^2} = \frac{1}{4\pi\varepsilon_0} \times \frac{3}{8} \times \frac{q^2}{d^2} = \frac{3}{8} F.$$