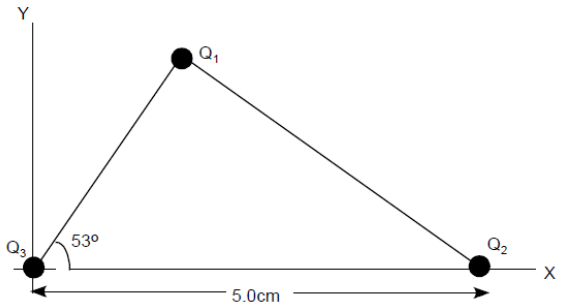
Answer on Question #42299-Physics-Electromagnetism

Three charges are arranged at the vertices of a right-angle triangle as shown, with Q1= 4μC =2Q2, and Q3 = - 3 μC.

[a] Determine the total potential energy of the three-charge system.

[b] Determine the work done by an external force to move Q2 from its present position to infinity.

Solution



[a] The initial potential energy,

$$U_i = k\frac{Q_1Q_2}{r_{12}} + k\frac{Q_1Q_3}{r_{13}} + k\frac{Q_3Q_2}{r_{32}}.$$

$$r_{32} = 5\cdot 10^{-2}m, r_{12} = r_{32}\sin 53° = 5\cdot 10^{-2}m\cdot 0.8 = 4\cdot 10^{-2}m, r_{13} = r_{32}\cos 53° = 5\cdot 10^{-2}m\cdot 0.6 = 3\cdot 10^{-2}m.$$

$$k = 9\cdot 10^9\frac{Nm^2}{C^2}, Q_1Q_2 = 4\mu C\cdot 2\mu C = 8\cdot 10^{-12}C^2, Q_1Q_3 = 4\mu C\cdot(-3\mu C) = -12\cdot 10^{-12}C^2,$$

$$Q_3Q_2 = (-3\mu C)\cdot 2\mu C = -6\cdot 10^{-12}C^2.$$

So

$$U_i = 9\cdot 10^9\left(\frac{8\cdot 10^{-12}}{4\cdot 10^{-2}} - \frac{12\cdot 10^{-12}}{3\cdot 10^{-2}} - \frac{6\cdot 10^{-12}}{5\cdot 10^{-2}}\right) = -2.88\,J.$$

[b] After Q_2 has been removed to infinity, the potential energy of the remaining charges is

$$U_f = k\frac{Q_1Q_3}{r_{13}} = -\frac{12\cdot 10^{-12}}{3\cdot 10^{-2}}\cdot 9\cdot 10^9 = -3.60J.$$

The work done by the external force is given by

$$\Delta W = \Delta U = U_f - U_i = -3.60J - (-2.88\,J) = -0.72J.$$

Answer: [a] $-2.88\,J$; [b] $-0.72J$.