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6.03 Electric Potential Energy

A charged object placed in an electric field will have electric potential energy, which will cause it to move.

Like the gravitational potential energy experienced from a point mass, the electric potential energy experienced from a point charge:

$E_p = \frac{kq_1q_2}{r}$ (J)

q_1 = charge 1 (point charge) (C)

q_2 = charge 2 (test charge) (C)

r = q_2's distance to q_1 (m)

k = Coulomb's constant 9.0×10^9 (Nm^2/kg^2)

compare this with Gravitational potential energy $= -\frac{GMm}{r}$

This is the electric potential energy in a non-uniform field.

Since electric potential energy is a scalar, the positive and the negative sign is used to show the work needed to move this charge (q_2) from infinity (∞) to a distance of (r) from point charge (q_1).

Ex. 1: How much work must be done to bring a 4.0 µC charged object to within 1.0 m of a 6.0 µC charged object from a long way away? (0.216 J)

q_2, r, q_1

$E_p = 0$ J $\quad F_p = \frac{kQ_1Q_2}{r \to \infty}$

E_p = ⊖ work done to bring q_2 closer to q_1

$= \frac{kQ_1Q_2}{r} = \frac{9\times10^9(6\times10^{-6})(4\times10^{-6})}{1}$

$= \boxed{0.216\text{ J}}$

What does it mean for this work to be positive? You need to put energy into the system to increase its potential energy.

Ex. 2: How much work must be done to bring a -7.0 µC charged object to within 0.5 m of a 5.0 µC charged object from a long way away? (-0.63 J)

$E_p = 0$ J b/c $r = \infty$

$W = E_p = \frac{kQ_1Q_2}{R} = \frac{9\times10^9(7.0\times10^{-6})(5\times10^{-6})}{0.5\text{ m}}$

$= -0.63$ J

What does it mean for this work to be negative? the system will lose potential energy going from $\infty \to 0.5$ m away ($E_p \to E_K$)

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Ex. 3: How much work is done against the electric field produced by a 5.0 uC charged object when a 0.030 uC charge is moved from a distance of 45 cm to 15 cm. (6.0×10^{-3} J)

Ex. 4: A proton is released 2.0×10^{-11} m from the centre of a 6.4×10^{-18} C fixed charge. What is the speed of the proton when it is 0.50 m from the charge (7.4×10^{5} m/s)

Ex. 5: The centers of two alpha particles are held 2.5×10^{-12} m apart, when they are released. Calculate the speed of each alpha particle when they are 0.75 m apart. (2.4×10^{5} m/s)

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