Electric potential energy definition physics

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Electric potential energy is a potential energy (measured in joules) that results from conservative Coulomb forces and is associated with the configuration of a particular set of point charges within a defined system. An object may be said to have electric potential energy by virtue of either its own electric charge or its relative position to other electrically charged objects.

The term "electric potential energy" is used to describe the potential energy in systems with time-variant electric fields, while the term "electrostatic potential energy" is used to describe the potential energy in systems with time-invariant electric fields.

The electric potential energy of a system of point charges is defined as the work required to assemble this system of charges by bringing them close together, as in the system from an infinite distance. Alternatively, the electric potential energy of any given charge or system of charges is termed as the total work done by an external agent in bringing the charge or the system of charges from infinity to the present configuration without undergoing any acceleration.

The electrostatic potential energy can also be defined from the electric potential as follows:

The SI unit of electric potential energy is joule (named after the English physicist James Prescott Joule). In the CGS system the erg is the unit of energy, being equal to 10-7 Joules. Also electronvolts may be used, 1 eV = 1.602x10-19 Joules.

The electrostatic potential energy, UE, of one point charge q at position r in the presence of a point charge Q, taking an infinite separation between the charges as the reference position, is:

where r is the distance between the point charges q and Q, and q and Q are the charges (not the absolute values of the charges--i.e., an electron would have a negative value of charge when placed in the formula). The following outline of proof states the derivation from the definition of electric potential energy and Coulomb"s law to this formula.

By definition, the change in electrostatic potential energy, UE, of a point charge q that has moved from the reference position rref to position r in the presence of an electric field E is the negative of the work done by the electrostatic force to bring it from the reference position rref to that position r.

When the curl ? x E is zero, the line integral above does not depend on the specific path C chosen but only on its endpoints. This happens in time-invariant electric fields. When talking about electrostatic potential energy, time-invariant electric fields are always assumed so, in this case, the electric field is conservative and Coulomb''s law can be used.

Using Coulomb''s law, it is known that the electrostatic force F and the electric field E created by a discrete point charge Q are radially directed from Q. By the definition of the position vector r and the displacement vector s, it follows that r and s are also radially directed from Q. So, E and ds must be parallel:

and the integral can be easily evaluated: