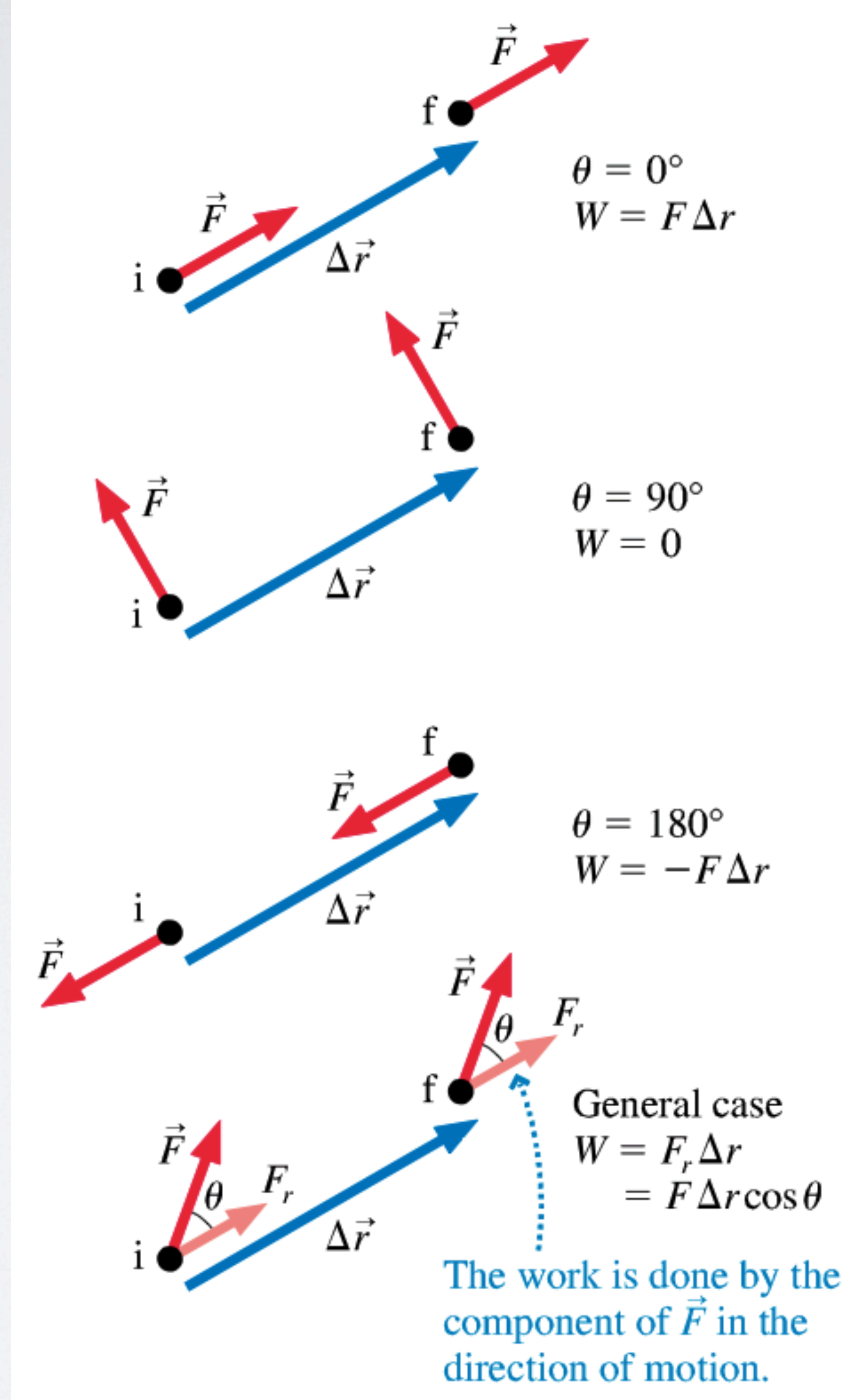
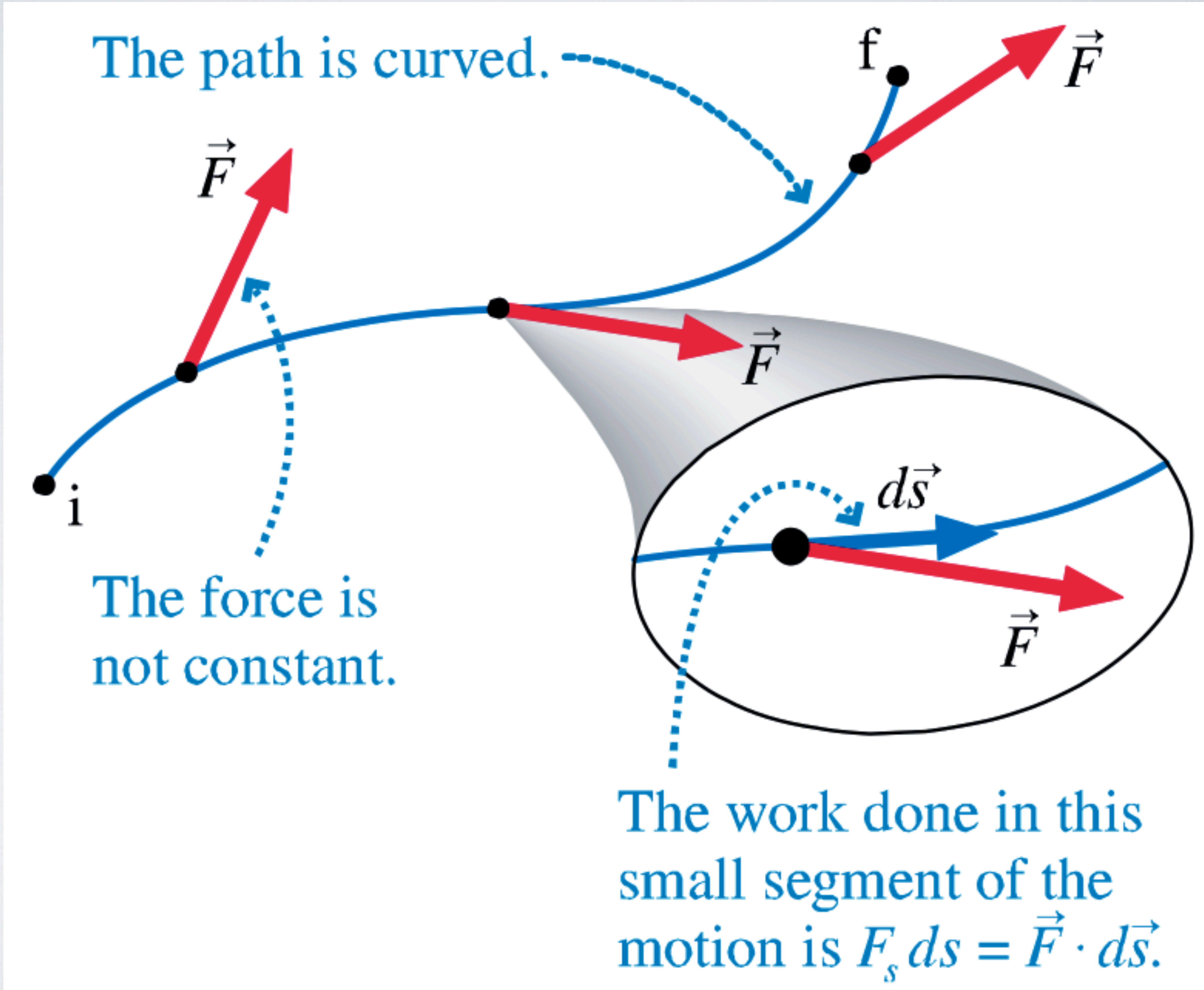
ELECTRIC POTENTIAL

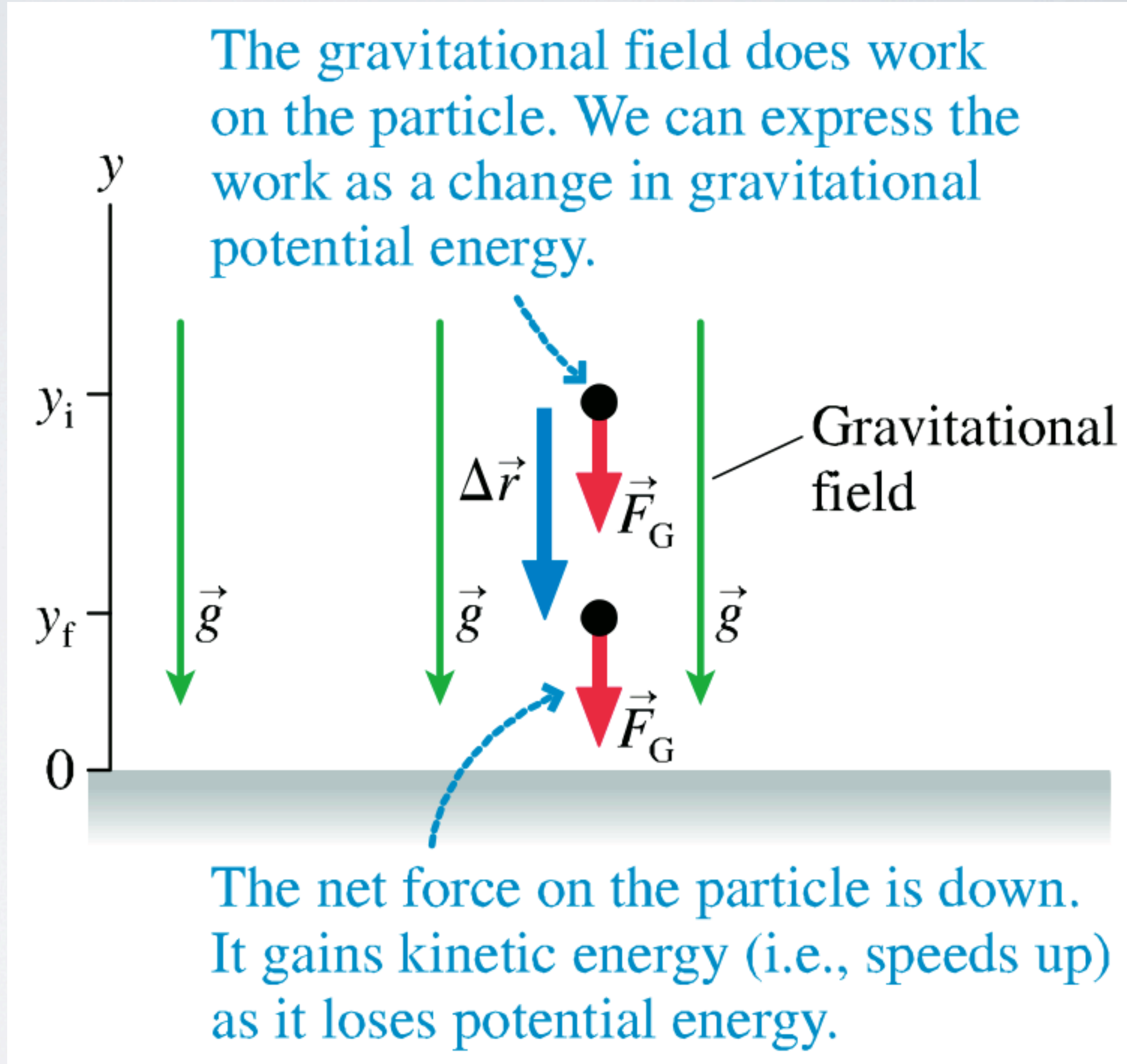
The work done by a constant force



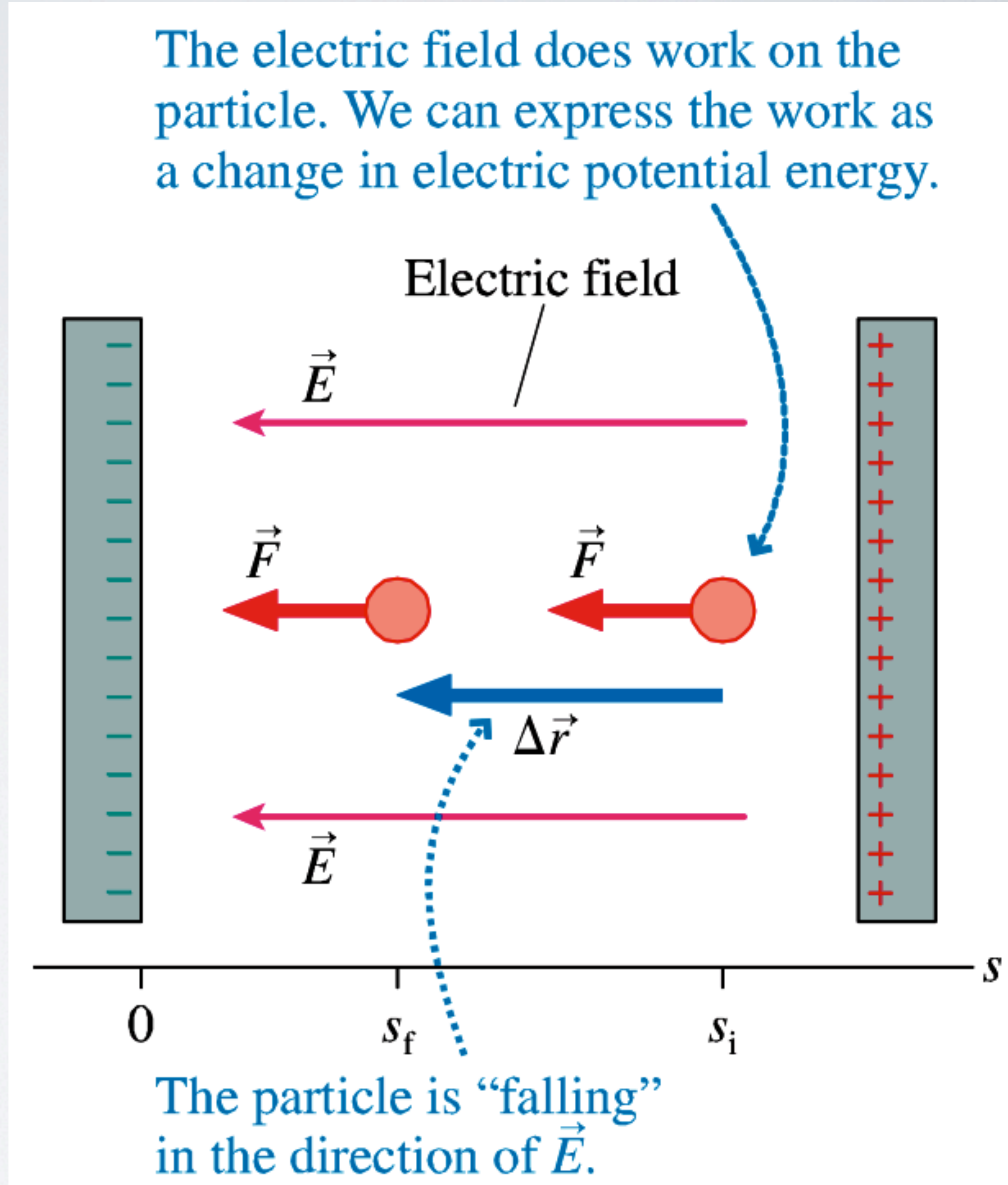
The work done along a curved path or by a variable force.



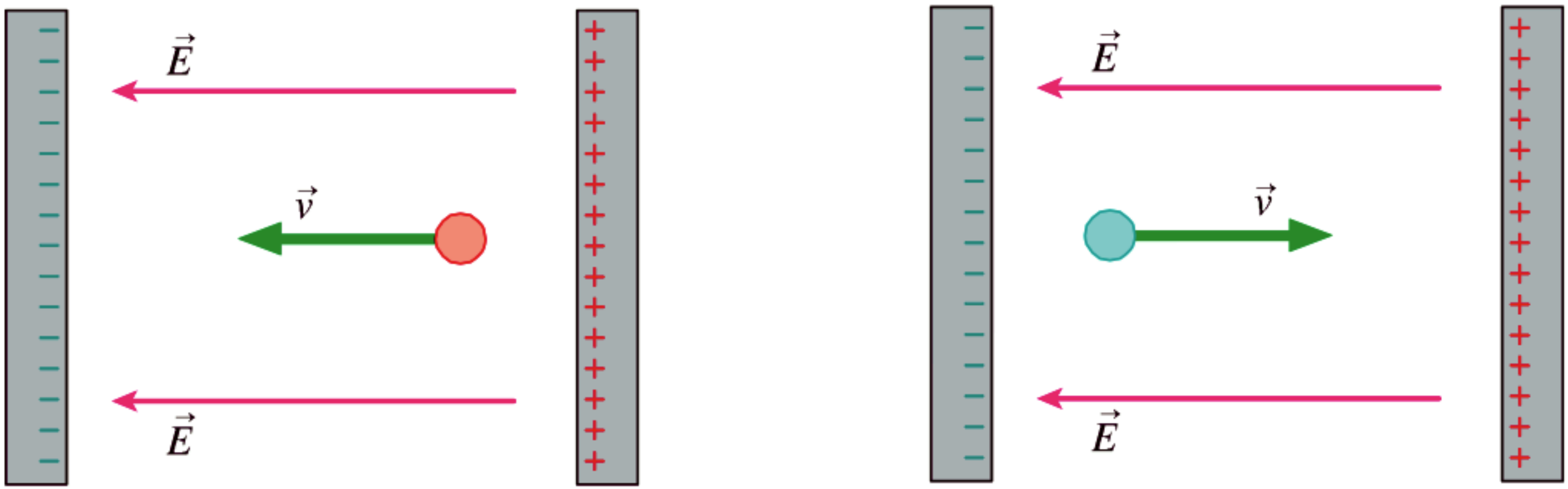
Potential energy is transformed into kinetic energy as a particle moves in a gravitational field.



The electric field does work on the charged particle.



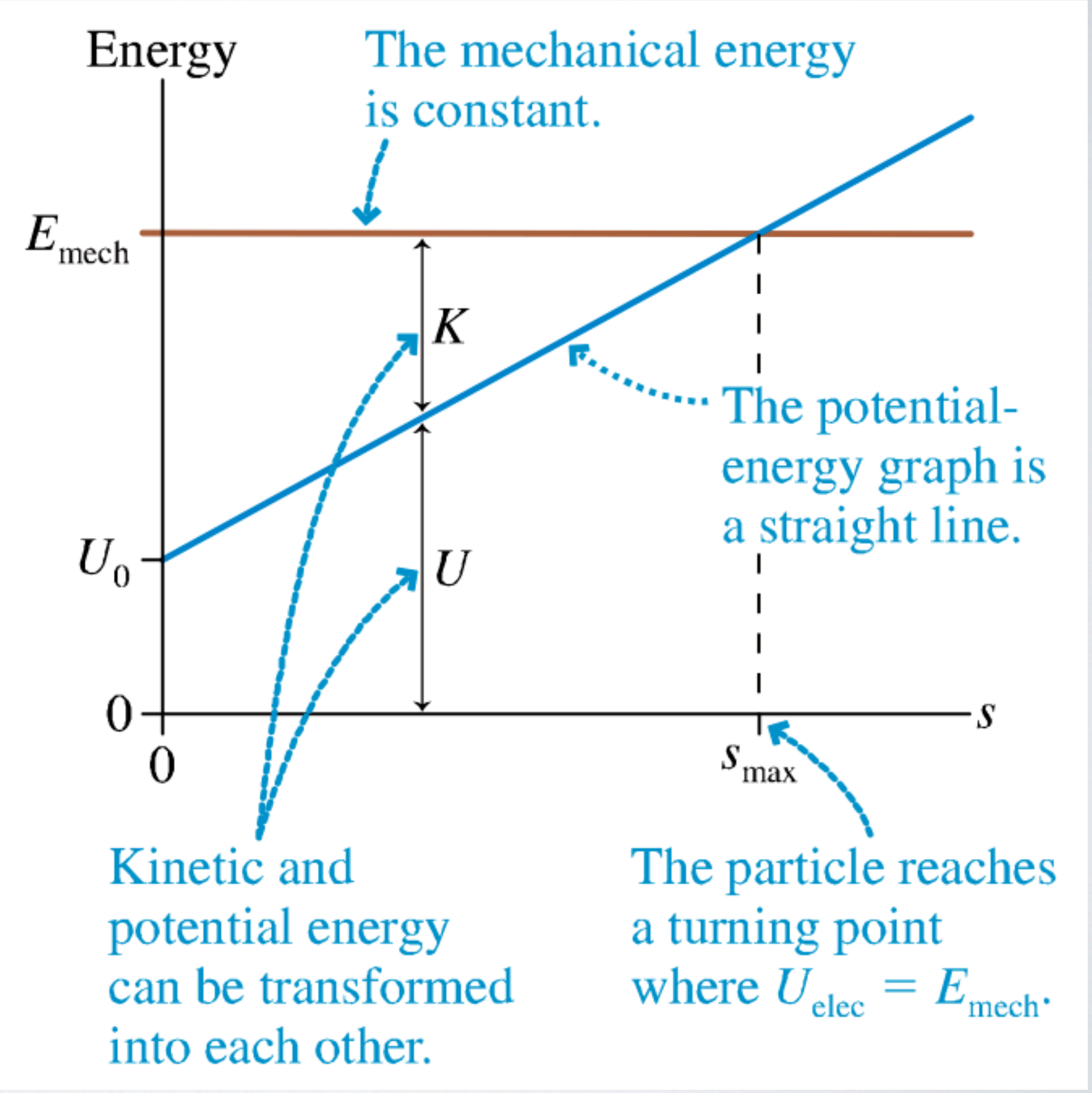
A charged particle of either sign gains kinetic energy as it moves in the direction of decreasing potential energy.



The potential energy of a positive charge decreases in the direction of $\vec{E}$. The charge gains kinetic energy as it moves toward the negative plate.

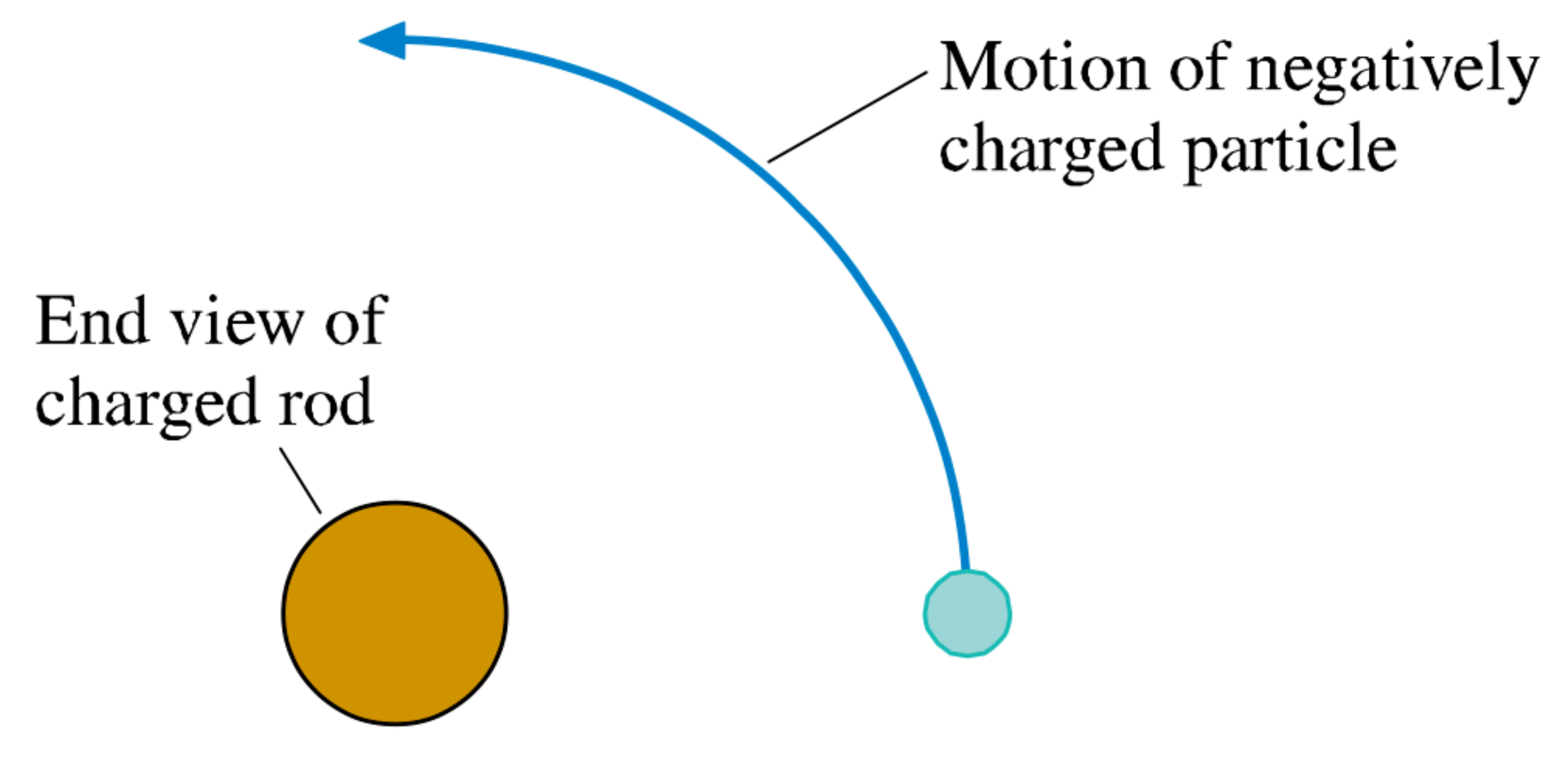
The potential energy of a negative charge decreases in the direction opposite to $\vec{E}$. The charge gains kinetic energy as it moves away from the negative plate.

The energy diagram for a positively charged particle in a uniform electric field.

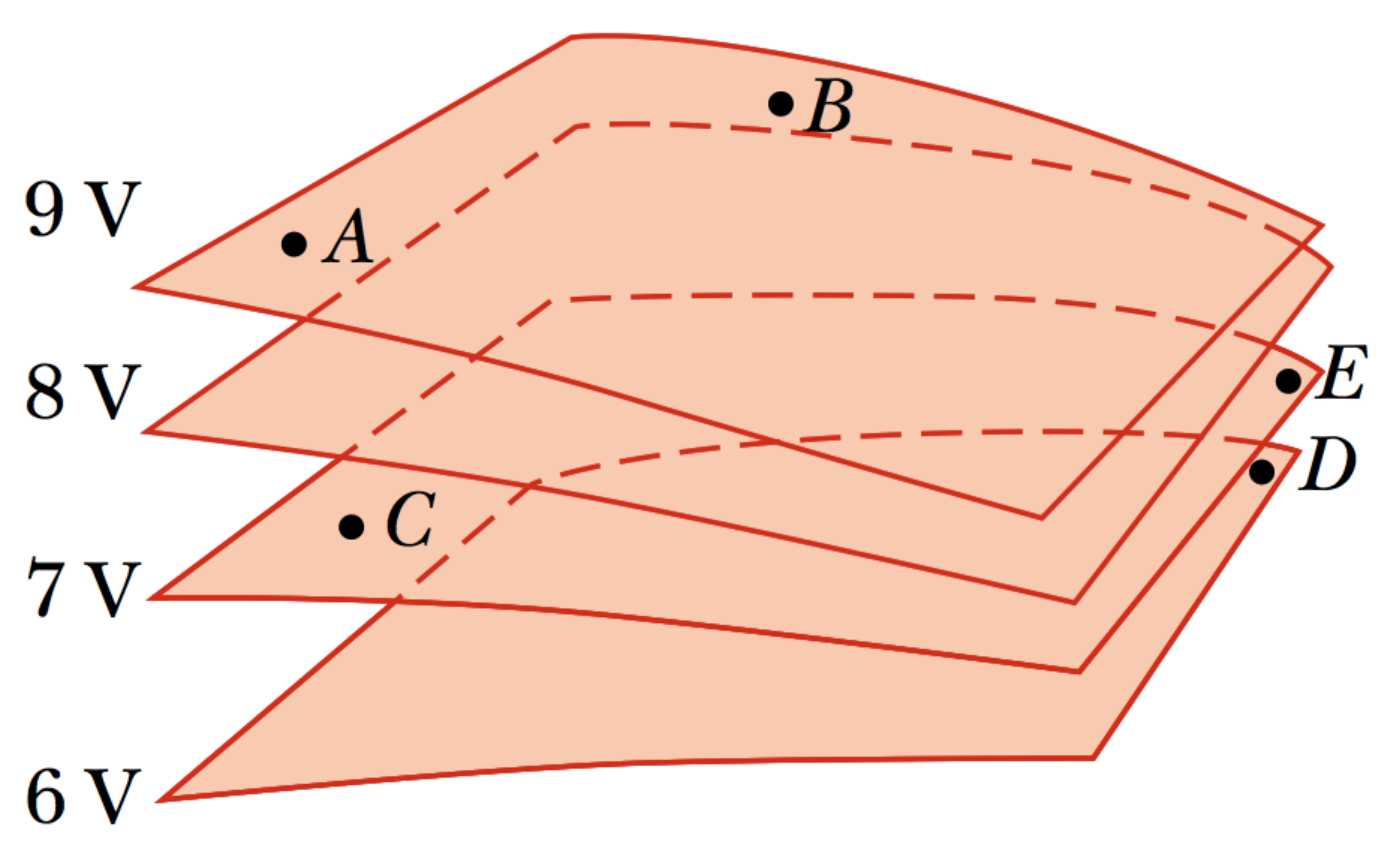


Exercise

A glass rod is positively charged. The figure shows an end view of the rod. A negatively charged particle moves in a circular arc around the glass rod. Is the work done on the charged particle by the rod's electric field positive, negative, or zero?



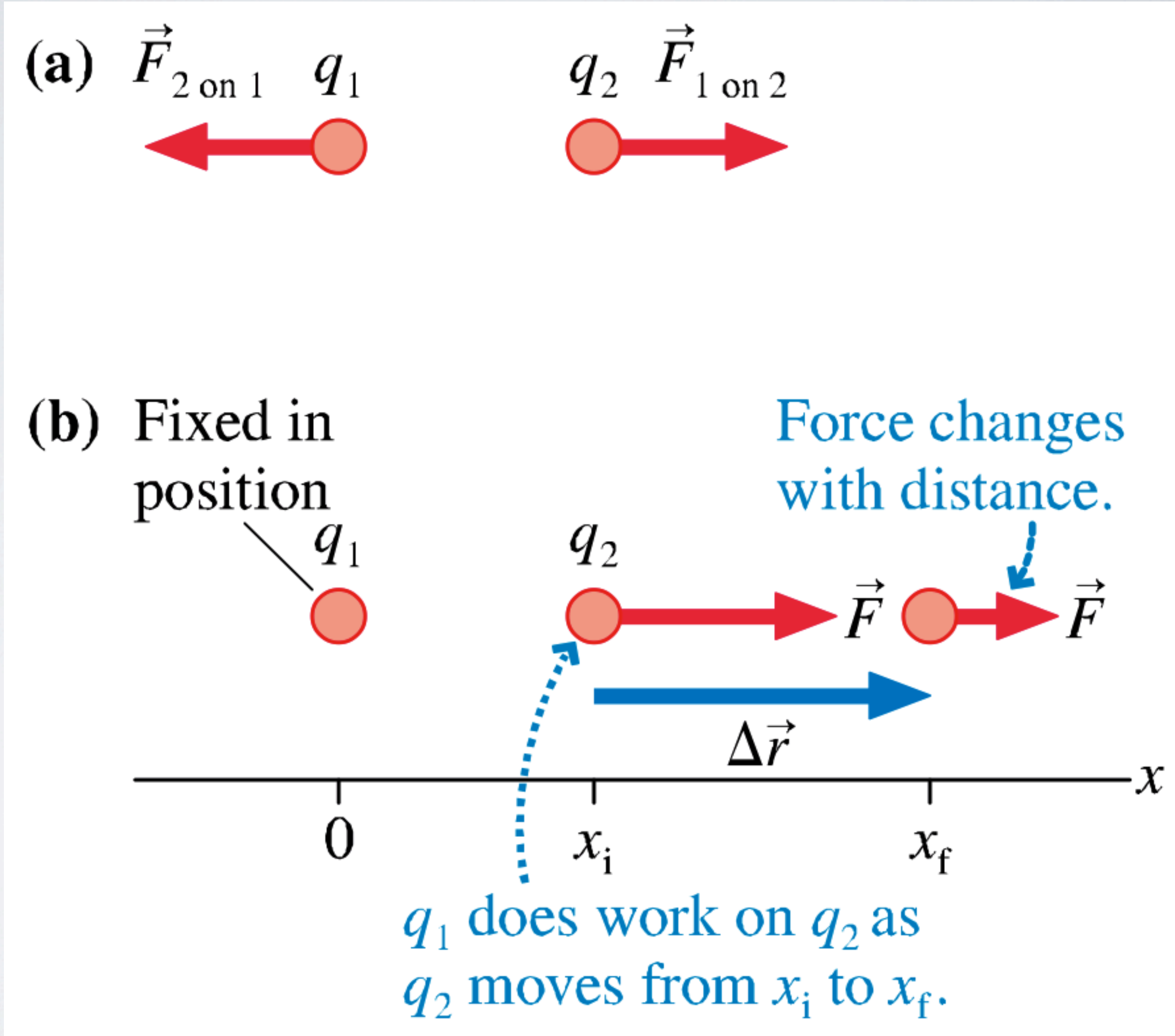
The labeled points in the figure are on a series of equipotential surfaces associated with an electric field. Rank (from greatest to least) the work done by the electric field on a positively charged particle that moves from *A* to *B*; from *B* to *C*; from *C* to *D*; from *D* to *E*.



Exercise

|| The electric field strength is 20,000 N/C inside a parallel-plate capacitor with a 1.0 mm spacing. An electron is released from rest at the negative plate. What is the electron's speed when it reaches the positive plate?

The Potential Energy of Point Charges



The interaction between two point charges.

The potential energy of the two charges is related to the work done by

$$\Delta U_{\text{elec}} = U_{\text{f}} - U_{\text{i}} = -W_{\text{elec}}(\text{i} \rightarrow \text{f}) = \frac{Kq_1q_2}{x_{\text{f}}} - \frac{Kq_1q_2}{x_{\text{i}}}$$

By comparing the left and right sides of the equation we see that the potential energy of the two-point-charge system is

$$U_{\text{elec}} = \frac{Kq_1q_2}{x}$$

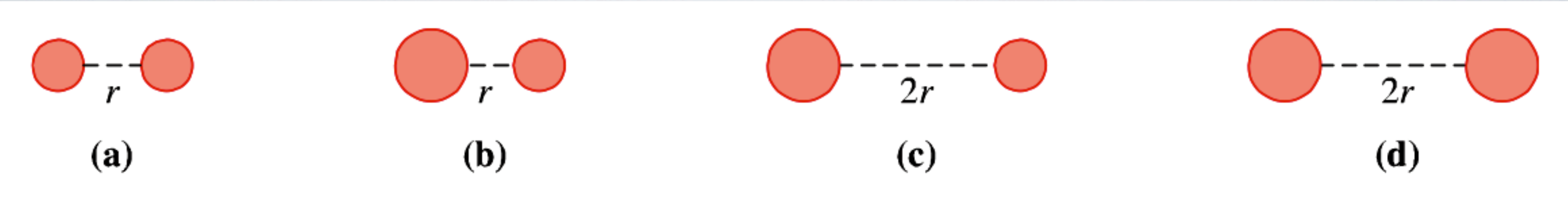
If more than two charges are present, the potential energy is the sum of the potential energies due to all pairs of charges:

$$U_{\text{elec}} = \sum_{i<j} \frac{Kq_iq_j}{r_{ij}}$$

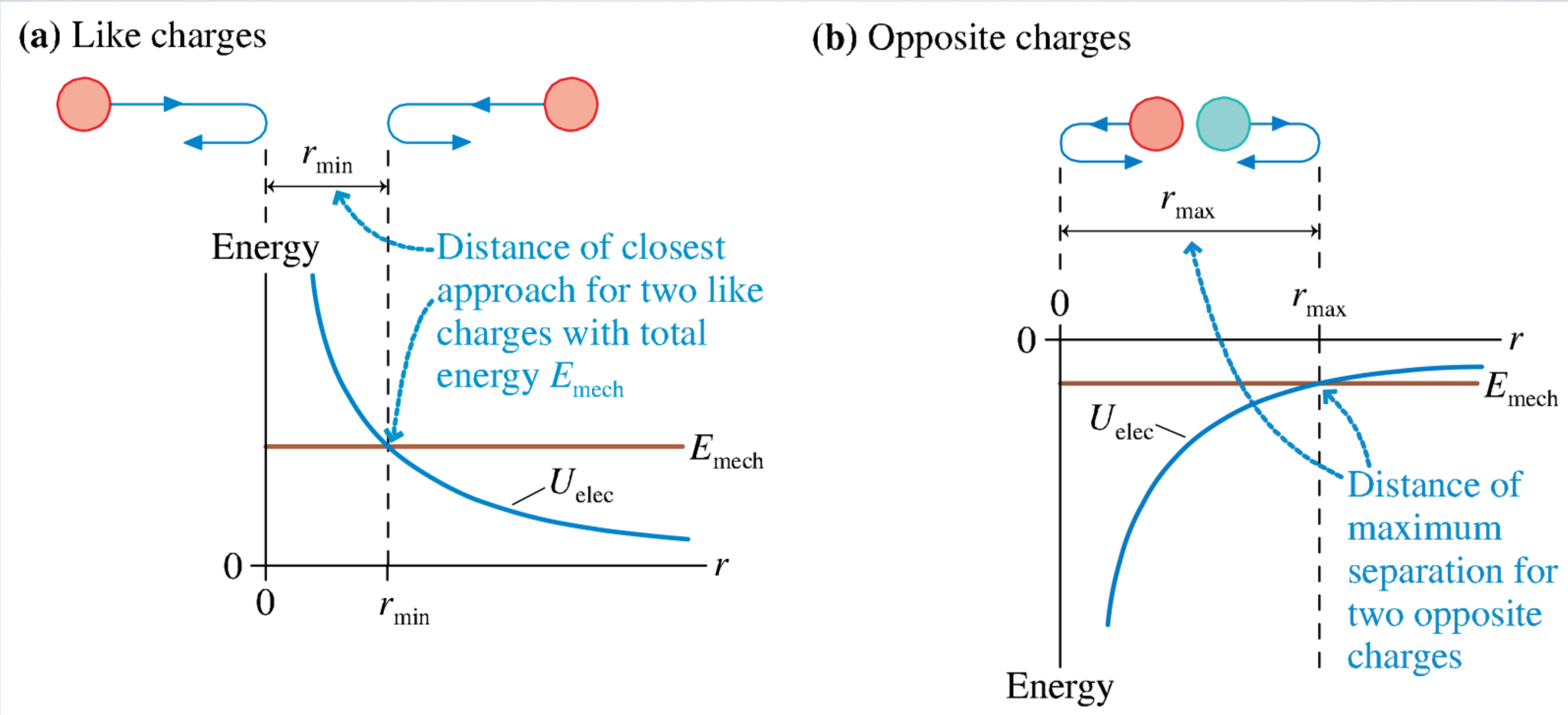
where r_{ij} is the distance between q_i and q_j. The summation contains the $i < j$ restriction to ensure that each pair of charges is counted only once.

Exercise

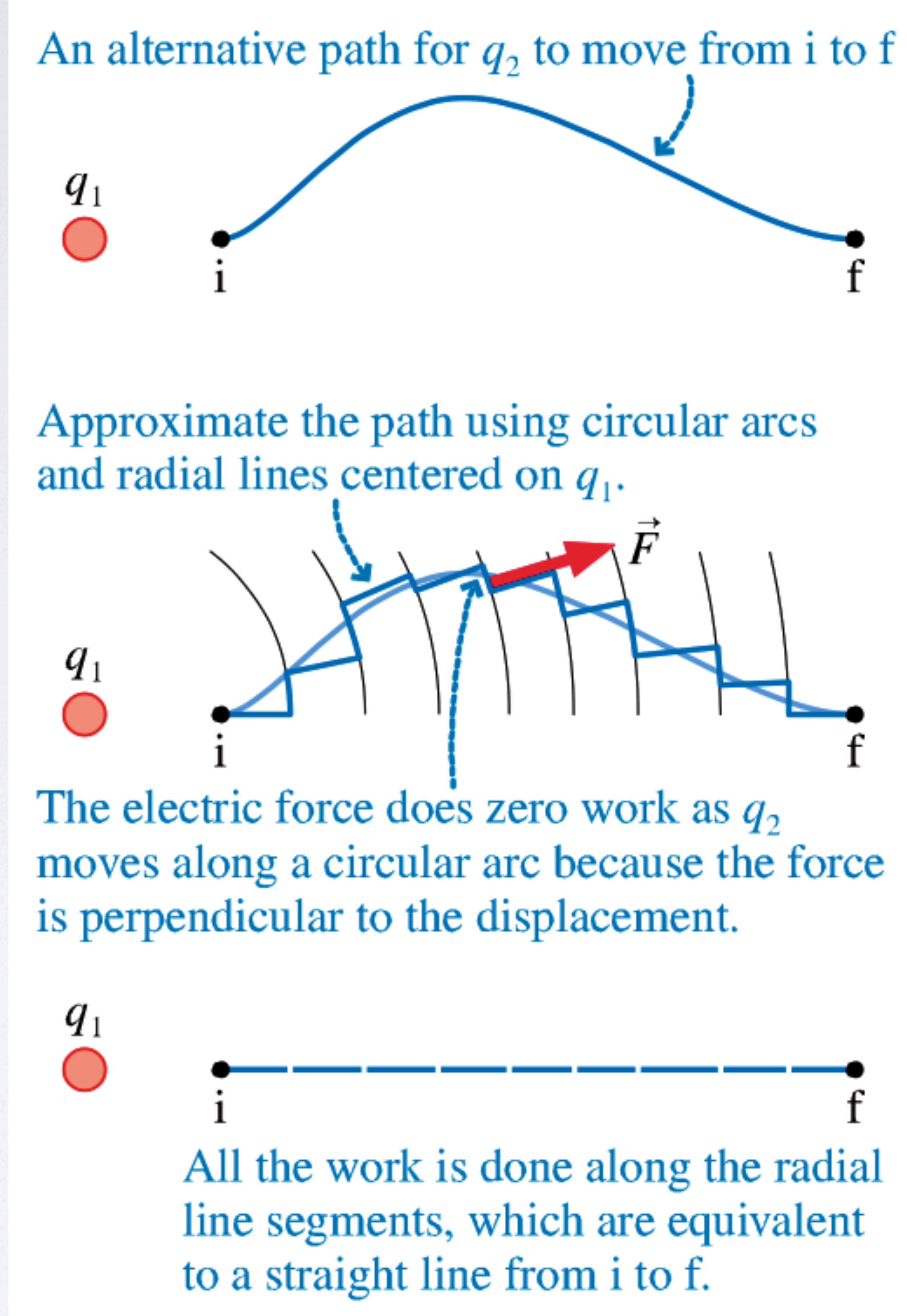
Rank in order, from largest to smallest, the potential energies U_a to U_d of these four pairs of charges, Each + symbol represents the same amount of charge.



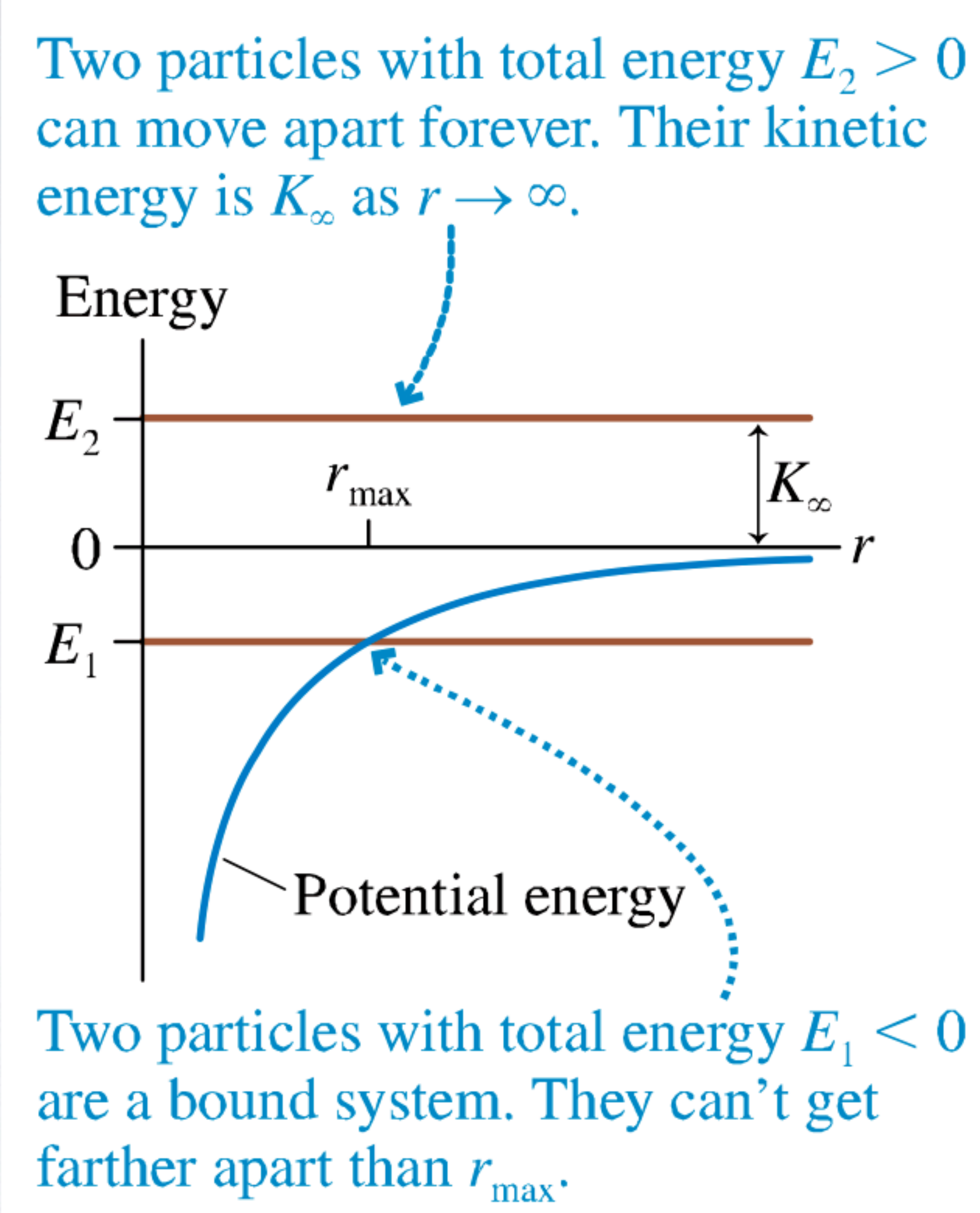
The potential-energy diagrams for two like charges and two opposite charges.



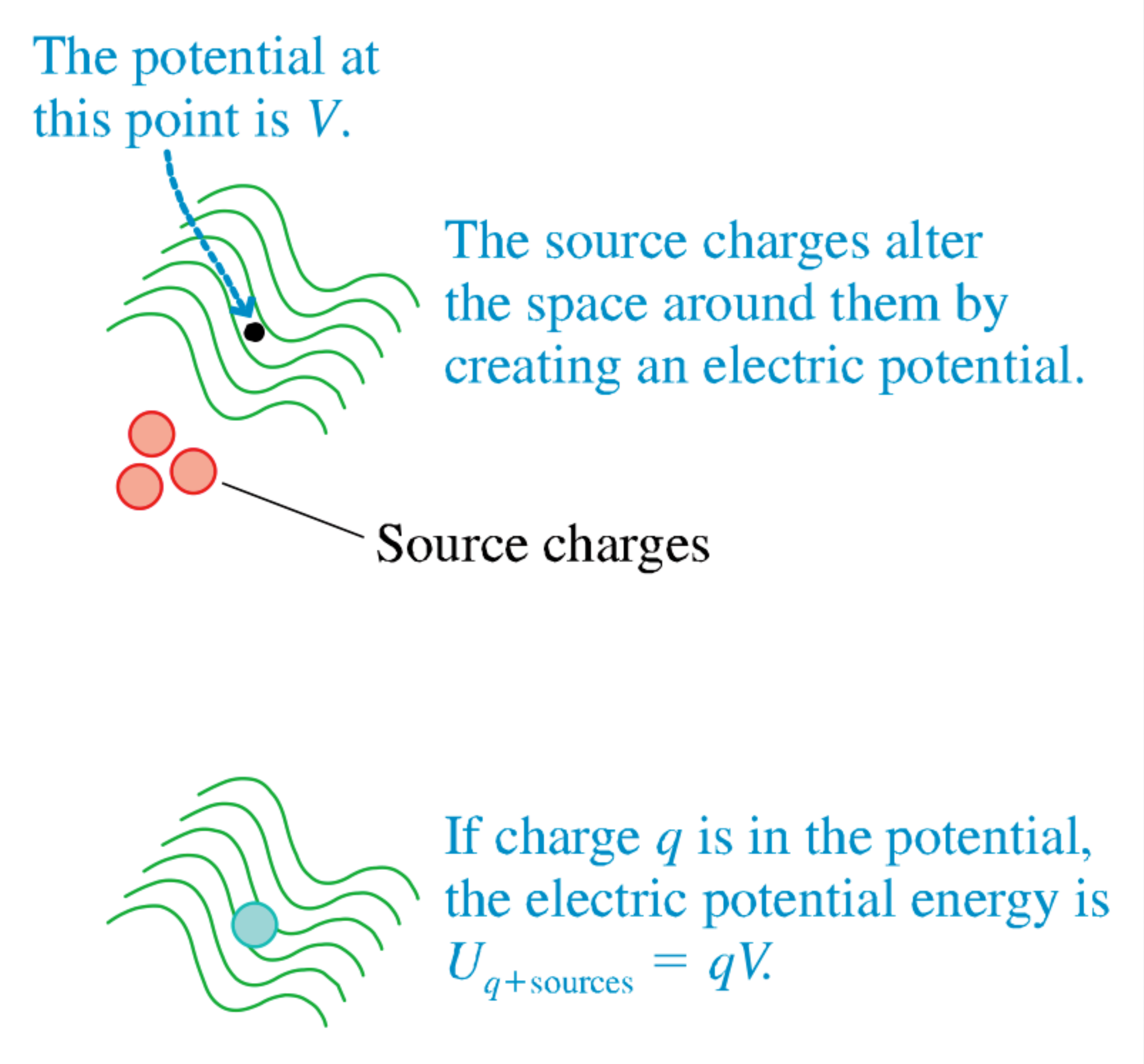
Calculating the work done as q_2 moves along a curved path from i to f.



A system with $E_{mech} < 0$
is a *bound system*.

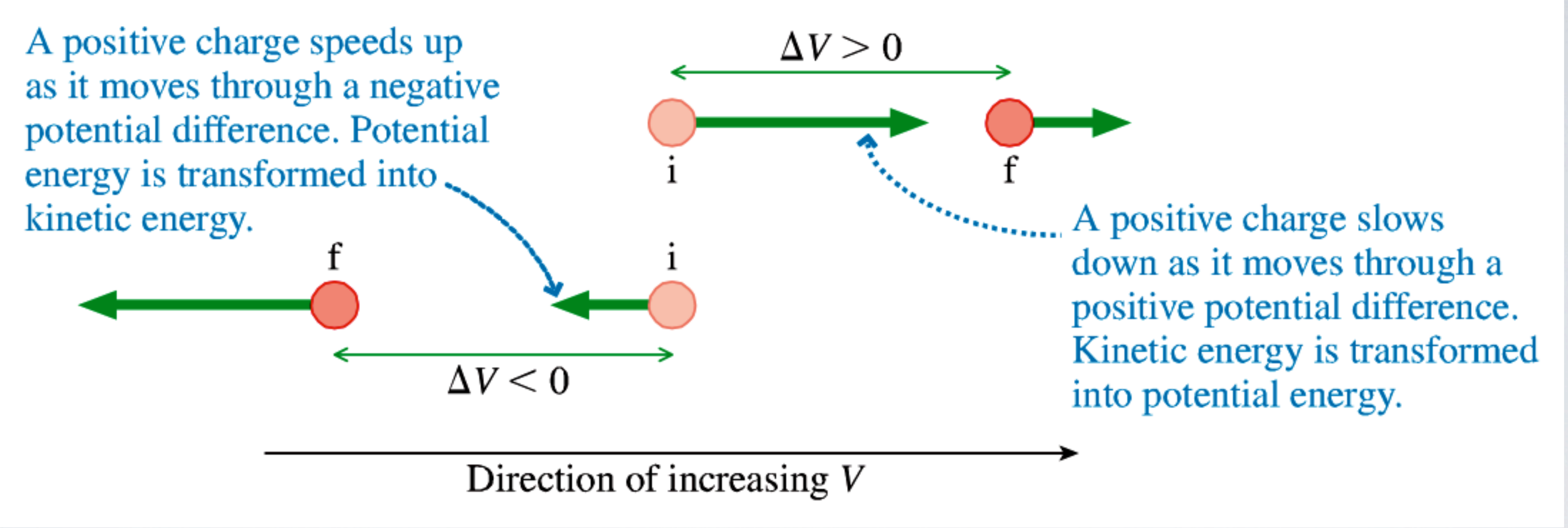


The Electric Potential



Source charges alter the space around them by creating an electric potential.

A charged particle speeds up or slows down as it moves through a potential difference.



Distinguishing electric potential and potential energy.

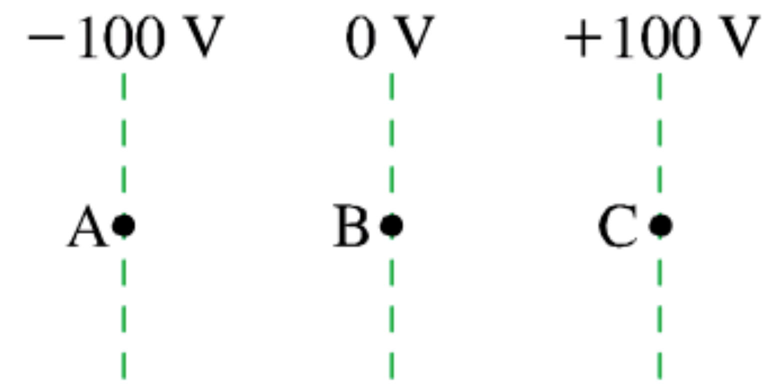
The *electric potential* is a property of the source charges and, as you'll soon see, is related to the electric field. The electric potential is present whether or not a charged particle is there to experience it. Potential is measured in J/C, or V.

The *electric potential energy* is the interaction energy of a charged particle with the source charges. Potential energy is measured in J.

Exercise

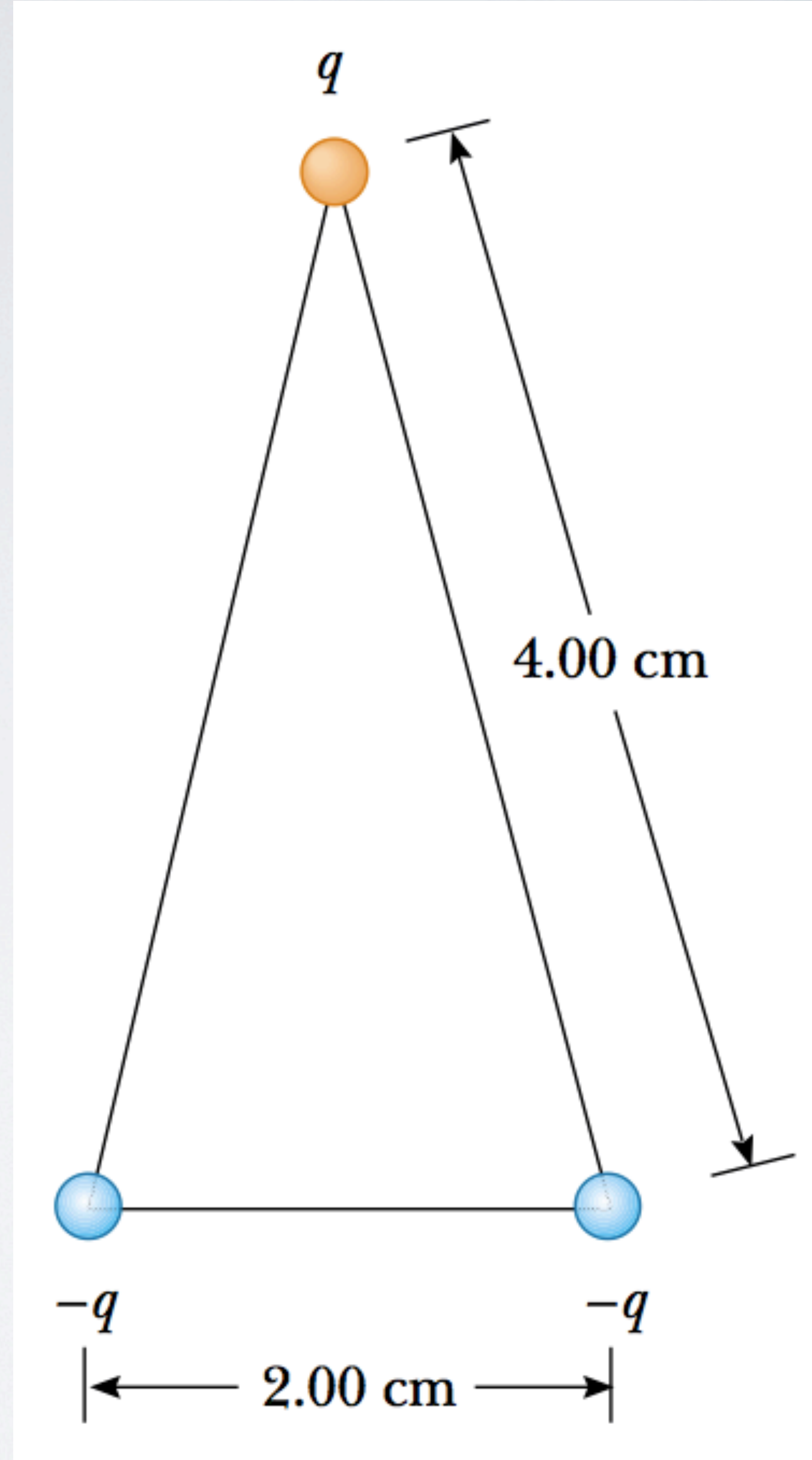
A proton is released from rest at point B, where the potential is 0 V. Afterward, the proton

a. Remains at rest at B.
b. Moves toward A with a steady speed.
c. Moves toward A with an increasing speed.
d. Moves toward C with a steady speed.
e. Moves toward C with an increasing speed.

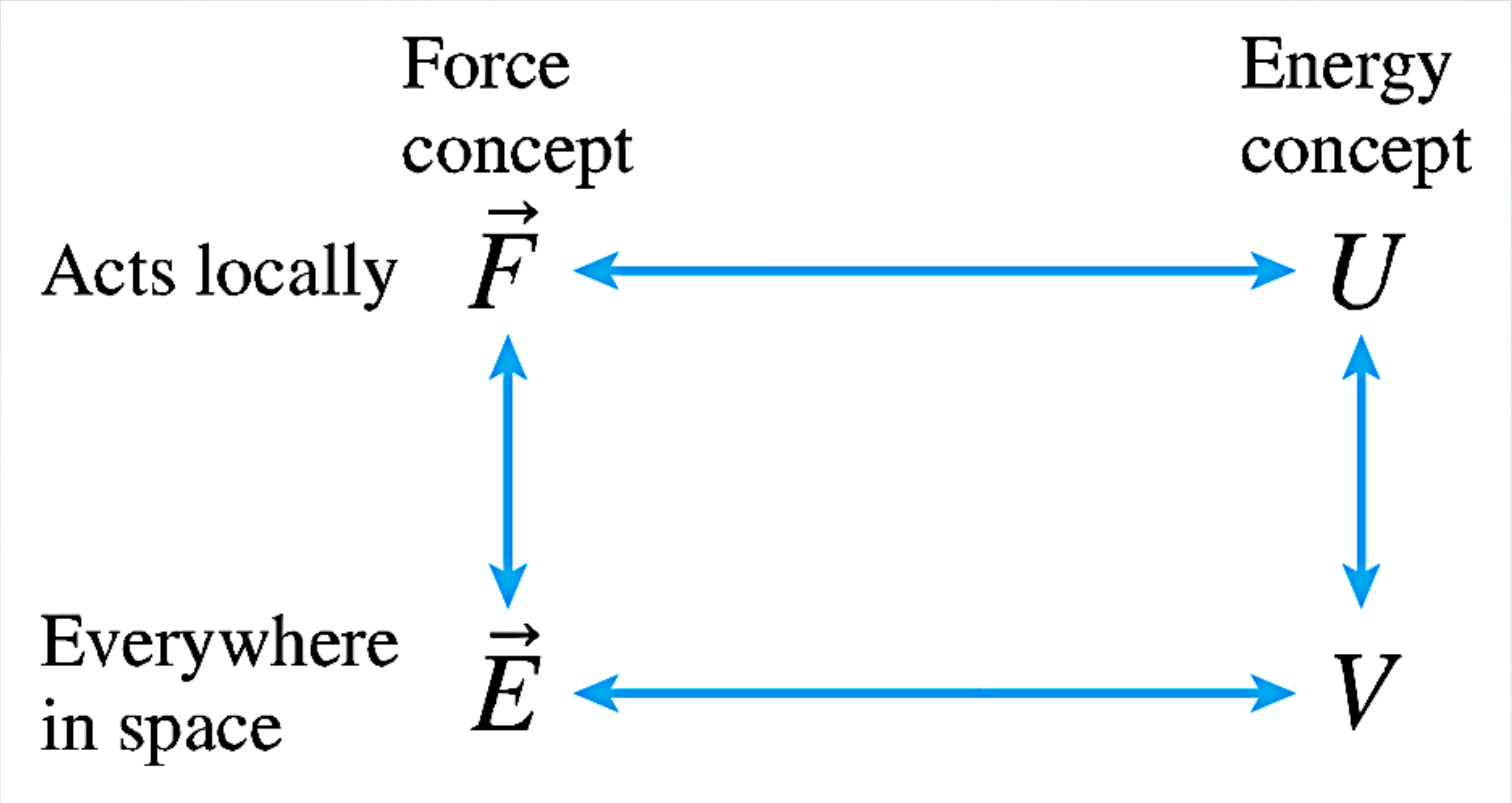


Serway P 25.21, p. 796

The three charges in the figure are at the vertices of an isosceles triangle. Calculate the electric potential at the midpoint of the base, taking $q = 7.00$ μC.



The four key ideas



Seatwork

Serway **25.5**, p. 795

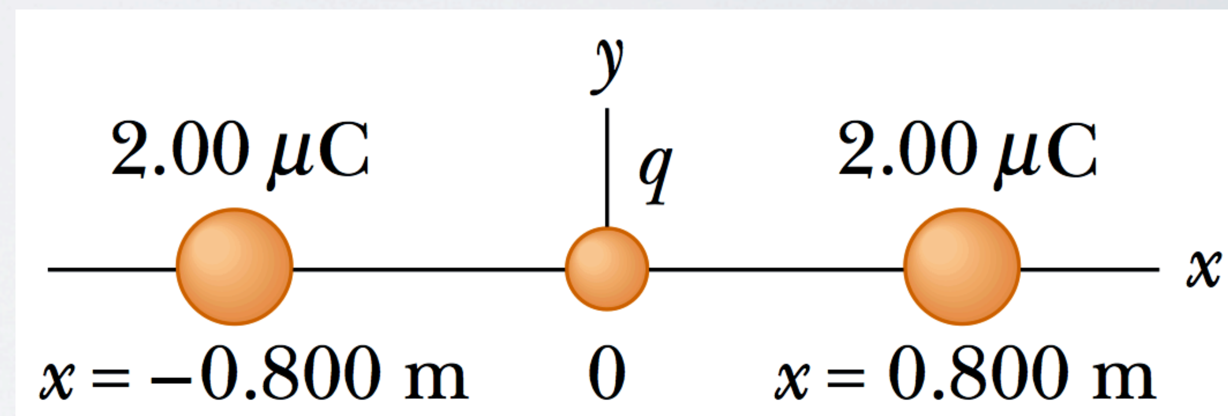
What potential difference is needed to stop an electron having an initial speed of 4.20×10^5 m/s?

Serway **25.9**, p. 795

An electron moving parallel to the *x* axis has an initial speed of 3.70×10^6 m/s at the origin. Its speed is reduced to 1.40×10^5 m/s at the point $x = 2.00$ cm. Calculate the potential difference between the origin and that point. Which point is at the higher potential?

Serway **25.17**, p. 796

Given two 2.00-μC charges, as shown in the figure, and a positive test charge $q = 1.28 \times 10^{-18}$ C at the origin, (a) what is the net force exerted on *q* by the two 2.00-μC charges? (b) What is the electric field at the origin due to the two 2.00-μC charges? (c) What is the electric potential at the origin due to the two 2.00-μC charges?



Serway **25.29**, p. 797

A small spherical object carries a charge of 8.00 nC. At what distance from the center of the object is the potential equal to 100 V? 50.0 V? 25.0 V? Is the spacing of the equipotentials proportional to the change in potential?