Topic D.2 Electric and magnetic fields:

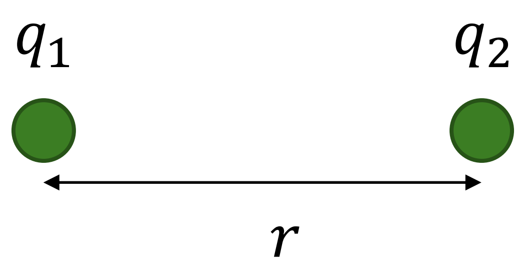
Electric potential energy and potential

Electric potential energy

Electric potential energy

- Electric potential energy is stored in any system of charges because of the forces between them.

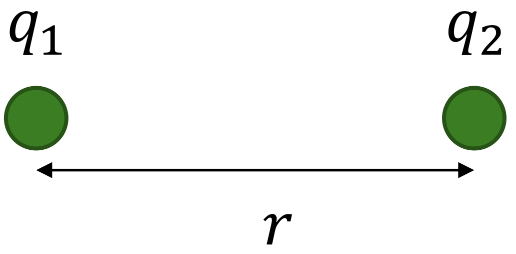
- The total electric potential energy of a system, Ep, is defined as the work done when bringing all the charges of the system to their present positions, assuming that they were originally at infinity.



Electric Potential Energy

- **Electric potential energy** of two **point charges** separated by a distance r

$$E_P = k\frac{q_1 q_2}{r}$$



Is the electric potential energy negative or positive??

Electric potential energy

- Electric potential energies can be negative (if the forces are attractive between opposite charges), or positive (if the forces are repulsive between similar charges). In other words, we need to supply energy to separate charges which are attracted to each other, but energy is released (to kinetic energy) as opposite charges are repelled apart from each other.

Electric potential energy

Question 1:

- Calculate the electric potential energy that was stored between two isolated spherical conductors: one had a radius of 2.5 cm and charge -4.7×10^{-8} C, the other had a radius of 1.5 cm and charge -6.3×10^{-8} C. Their surfaces were separated by 1.7 cm.
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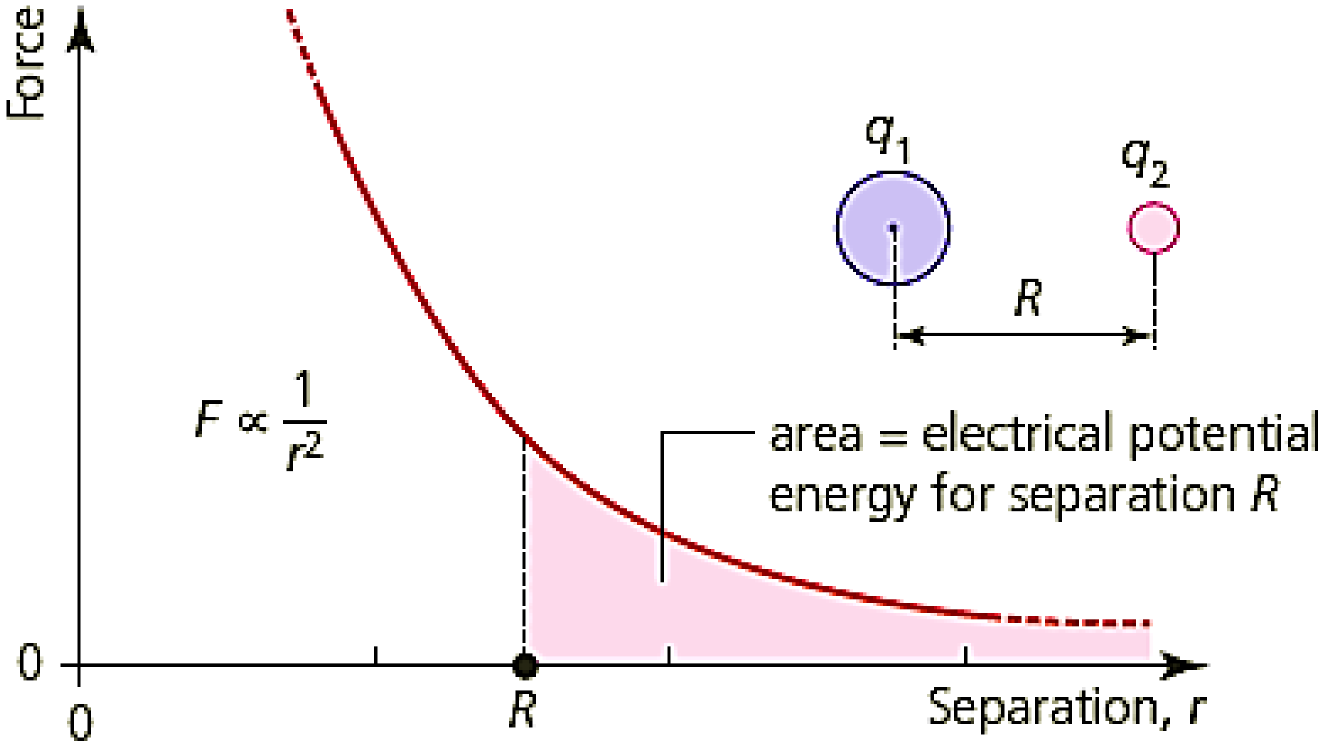
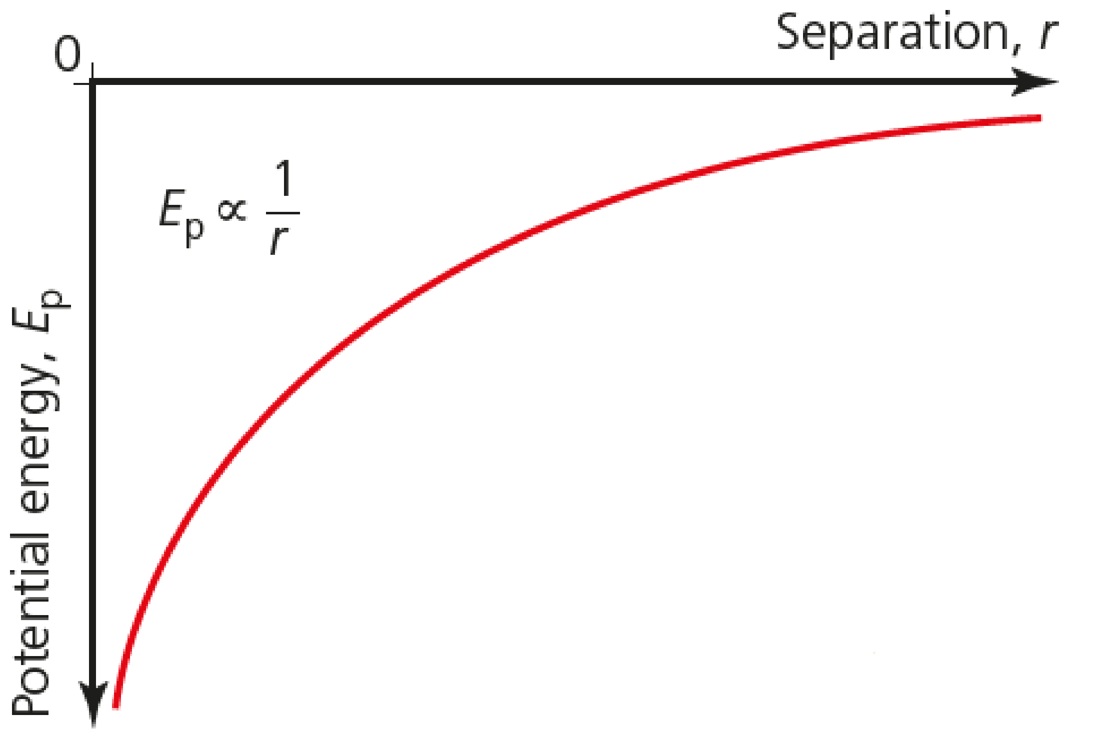
Electric potential energy

- Answer : Ep = $+4.7 \times 10^{-4}$ J
- The energy is positive because the charges are repelled from each other and they would gain kinetic energy if they were free to move.

Electric potential energy

- Electrical potential energy can be determined from the area under a force–distance graph, as shown in figure for similar charges.
- 

Electric potential energy



Electric potential energy variation with separation between oppositely charged point charges.

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Eectric potential

Electric potential

- The concept of **electric potential**, V_e, is used to describe points in the space around charges.

- Electric potential can be considered as electric potential energy *per unit charge*.

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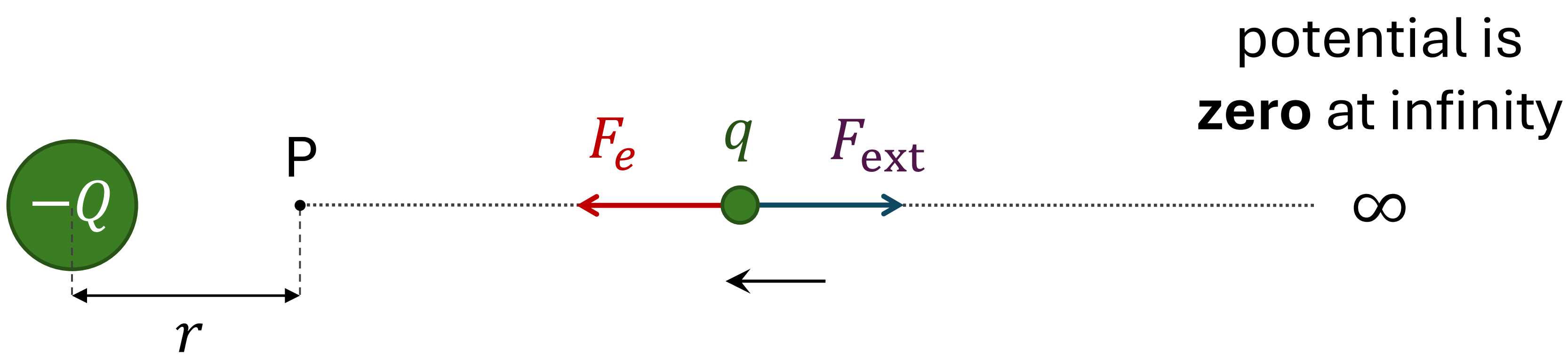
Electric potential

- **The electric potential** at a point is defined as the work done per unit charge (1 C) in bringing a small positive test charge from infinity to that point.



Electric potential

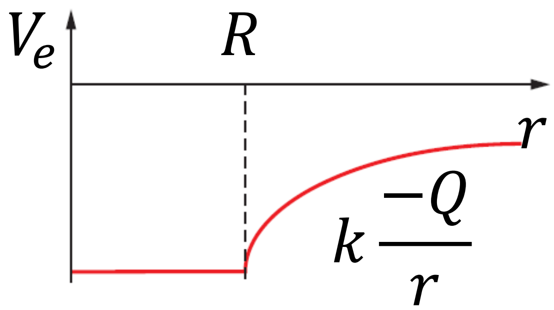
- **The electric potential** at a point is defined as the work done per unit charge (1 C) in bringing a small positive test charge from infinity to that point.

$$V_e = k\frac{Q}{r}$$

The SI unit for electric potential is J C^{-1}.It is called volt (V).

Electric potential

- The potential around a negative charge will be negative. Increasing the distance, r, from the charge, −Q, reduces the magnitude of the negative potential, which is equivalent to an increase in potential.



- The potential around a positive charge will be positive. Increasing the distance, r, from the charge, +Q, reduces the magnitude of the positive potential, which is equivalent to a decrease in potential.

Electric potential

WORKED EXAMPLE D2.10

Calculate the electric potential due to a point charge of -1.00×10^{-8} C at a distance of:

a 1.00 m **b** 2.00 m.

Answer

a $V_e = \frac{kQ}{r} = \frac{(8.99 \times 10^9) \times (-1.00 \times 10^{-8})}{1.00} = -89.9\,\text{V}$

b $V_e = \frac{kQ}{r} = \frac{(8.99 \times 10^9) \times (-1.00 \times 10^{-8})}{2.00} = -45.0\,\text{V}$

The potential increases by 45.0 V when moving from 1.00 m to 2.00 m from the charge.

Electric potential

Compare :

- **The electric potential** at a point is defined as the work done per unit charge (1 C) in bringing a small positive test charge from infinity to that point.
- $$V_e = k\frac{Q}{r}$$

- **The electric potential energy of a system**, Ep, is defined as the work done when bringing all the charges of the system to their present positions, assuming that they were originally at infinity.

$$E_P = k\frac{q_1 q_2}{r}$$