Electric Field

QUIZ Check your understanding:

Suppose the electric field lines in a region of space are straight lines. If a charged particle is released from rest in that region, will the trajectory of the particle be along a field line?

QUIZ Check your understanding:

(a) A negative point charge moves along a straight-line path directly toward a stationary positive point charge. Which aspect(s) of the electric force on the negative point charge will remain constant as it moves?
(i) Magnitude (ii) direction; (iii) both magnitude and direction; (iv) neither magnitude nor direction.

(b) A negative point charge moves along a circular orbit around a positive point charge. Which aspect(s) of the electric force on the negative point charge will remain constant as it moves? (i) Magnitude; (ii) direction; (iii) both magnitude and direction; (iv) neither magnitude nor direction.

Yes!

$\vec{a} = \frac{\vec{F}}{m} = \frac{q}{m}\vec{E}$ with $\vec{v}_0 = 0$

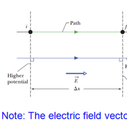
$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ Q ---> +Q

(a) (ii)

(b) (i)

Calculating the Potential from the Field

In case of a **uniform** field:



$$\vec{E}\cdot d\vec{s} = E\,ds\cos 0 = E\,ds$$

$$V_f - V_i = -E\int_i^f ds$$

$$\Rightarrow \boxed{\Delta V = -E\,\Delta x}$$

Note: The electric field vector points from higher potential toward lower potential.

QUIZ Check your understanding:

Assume the test charge is positive. (a) What is the direction of the electric field associated with the surfaces? (b) For each path, is the work we do positive, negative, or zero? (c) Rank the paths according to the work we do, greatest first. (d) What happens if we consider an electron?

$\vec{E}$

(a) ---->

(b) $W_1 > 0$, $W_3 > 0$

$W_2 > 0$, $W_4 < 0$

$W_5 > 0$

(c) W_3; W_1 & W_2 & W_5; W_4

(d) $W \to -W$

Electric Field and Electric Potential

QUIZ Check your understanding:

(a) If the electric potential at a certain point is zero, does the electric field at that point have to be zero?
(b) If the electric field at a certain point is zero, does the electric potential at that point have to be zero?

QUIZ Check your understanding:

In a certain region of space the potential is given by $V = A + Bx + Cy^3 + Dxy$, where A, B, C, and D are positive constants. Which of these statements about the electric field $\boldsymbol{E}$ in this region of space is correct? (There may be more than one correct answer.)
(i) Increasing the value of A will increase the value of $\boldsymbol{E}$ at all points; (ii) increasing the value of A will decrease the value of $\boldsymbol{E}$ at all points; (iii) $\boldsymbol{E}$ has no z-component; (iv) the electric field is zero at the origin (x = 0, y = 0, z = 0).

(a) No

(b) No

$\vec{E} = -\nabla V = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y}\right) = -\left(B + Dy\,\hat{i} - (3Cy^2 + Dx)\,\hat{j}\right)$

(iii)

Capacitors in Parallel and in Series

QUIZ Check your understanding:

(a) How should you connect a 4 μF capacitor and an 8 μF capacitor so that the 4 μF capacitor has a greater potential difference across it than the 8 μF capacitor?
(ii) Series; (ii) parallel; (iii) either series or parallel; (iv) neither series nor parallel.

(b) How should you connect them so that the 4 μF capacitor has a greater charge than the 8 μF capacitor?
(i) Series; (ii) parallel; (iii) either series or parallel; (iv) neither series nor parallel.

QUIZ Check your understanding:

You want to connect a 4 μF capacitor and an 8 μF capacitor. With which type of connection will the 4 μF capacitor have a greater amount of stored energy than the 8 μF capacitor?
(i) Series; (ii) parallel; (iii) either series or parallel; (iv) neither series nor parallel.

$V_1 = V_2$ / $q_1 = q_2 \Rightarrow$

$V_1 = \frac{V_2}{2}$

$\frac{q_1}{C} = \frac{q_2}{2C} \to q_2 = 2q_1$ (a) i (b) iv

$U = \frac{q^2}{2C} = \frac{CV^2}{2}$ (i)

Series: $U_1 = \frac{q^2}{2C}$, $U_2 = \frac{q^2}{4C}$

Paral: $U_1 = \frac{CV^2}{2}$, $U_2 = \frac{2CV^2}{2} = CV^2$

Capacitor with a Dielectric

QUIZ Check your understanding:

The space between the plates of an isolated parallel-plate capacitor is filled by a slab of dielectric with dielectric constant K. The two plates of the capacitor have charges Q and $-Q$. You pull out the dielectric slab. If the charges do not change, how does the energy in the capacitor change when you remove the slab?
(i) it increases; (ii) it decreases; (iii) it remains the same.

$U = \frac{q^2}{2C}$ $C = KC_0$

$U_0 = \frac{q^2}{2C_0} = \frac{Kq^2}{2C}$

Resistance and Resistivity

QUIZ Check your understanding:

Suppose you increase the voltage across the copper wir. The increased voltage causes more current to flow, which makes the temperature of the wire increase. (The same thing happens to the coils of an electric oven or a toaster when a voltage is applied to them.) If you double the voltage across the wire, the current in the wire increases. By what factor does it increase? (i) 2; (ii) greater than 2; (iii) less than 2.

$I = \frac{V}{R} \to \frac{2V}{\alpha R}$ $\alpha > 1$

Single Loop Circuits

QUIZ Check your understanding:

Rank the following circuits in order from highest to lowest current: (i) A 1.4 Ω resistor connected to a 1.5 V battery that has an internal resistance of 0.10 Ω; (ii) a 1.8 Ω resistor connected to a 4.0 V battery that has a terminal voltage of 3.6 V but an unknown internal resistance; (iii) an unknown resistor connected to a 12.0 V battery that has an internal resistance of 0.20 Ω and a terminal voltage of 11.0 V.

QUIZ Check your understanding:

Rank the following circuits in order from highest to lowest values of the net power output of the battery. (i) A 1.4 Ω resistor connected to a 1.5 V battery that has an internal resistance of 0.10 Ω; (ii) a 1.8 Ω resistor connected to a 4.0 V battery that has a terminal voltage of 3.6 V but an unknown internal resistance; (iii) an unknown resistor connected to a 12.0 V battery that has an internal resistance of 0.20 Ω and a terminal voltage of 11.0 V.

(i) 1A

(ii) 2A $\Rightarrow$ (iii), (ii), (i)

(iii) 5A

$P = V_{ab} I$

(i) 1,4W

(iii) 7,2W $\Rightarrow$ (iii), (ii), (i)

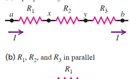
(iii) 55W

Resistors in Parallel and in Series

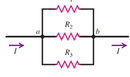
QUIZ Check your understanding:

Suppose all three of the resistors shown in figures have the same resistance, so $R_1 = R_2 = R_3 = R$. Rank the four arrangements shown in parts (a)–(d) in order of their equivalent resistance, from highest to lowest.

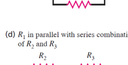
(a) R_1, R_2, and R_3 in series



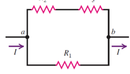
(b) R_1, R_2, and R_3 in parallel



(c) R_1 in series with parallel combination of R_2 and R_3



(d) R_1 in parallel with series combination of R_2 and R_3



(a) $3R$ (b) $\frac{R}{3}$

(c) $\frac{3}{2}R$, (d) $\frac{2}{3}R$

$\Rightarrow$ (a), (c), (d), (b)