Capacitance

PH 112

$dV = -E_x \, dx$

$E_x = -\frac{\partial V}{\partial x}$ $\quad E = -\nabla V$

$\nabla E = \langle \frac{\partial V}{\partial x}, \frac{\partial V}{\partial y}, \frac{\partial V}{\partial z} \rangle$

Example #1

$E_x = -6x - 2y \quad E_y = -2x \quad E_z = 2z$

$E = \boxed{\langle -6x-2y, -2x, 2z \rangle}$

Example #2

$E_x = 3x^2 - 6x \quad E_x(2) = 12 - 12 = \boxed{0}$

$emf = \frac{W}{q}$

Capacitor stores energy which can be released in a controlled manner

$C = \frac{Q}{V}$ F $\quad$ capacitance - ratio of charge to potential difference

$= \frac{A\varepsilon_0}{d}$ $\quad$ depends on geometry

Example #3

$E = \frac{Q}{2\pi\varepsilon_0 L r} \quad V = \frac{Q}{2\pi\varepsilon_0 L} \ln\left(\frac{B}{A}\right)$

$C = \boxed{2\pi\varepsilon_0 L / \ln\left(\frac{B}{A}\right)}$

Example #4

$C = \boxed{2\pi\varepsilon_0 L / \ln\left(\frac{B}{A}\right) + \ln\left(\frac{D}{C}\right)}$

Capacitors in parallel

$C_{tot} = C_1 + C_2 = \frac{Q_1 + Q_2}{V}$

V is the same

Capacitors in series

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

Q is the same

Example #5

$C_{11} = C_1 + C_2$

$\frac{1}{C_{eq}} = \frac{1}{C_{11}} + \frac{1}{C_3}$

$\boxed{C_{eq} = C_3(C_1 + C_2) / C_1 + C_2 + C_3}$

$dW = \frac{q}{C} dq$

$W = \frac{1}{2} C V^2 = \frac{Q^2}{2C}$

$U = \frac{1}{2} \varepsilon_0 E^2 A d$

$u = \frac{U}{Vol} = \frac{1}{2} \varepsilon_0 E^2 \ J/m^3$