PhysicsTutor

Capacitor

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Problem:

- A parallel-plate capacitor has a charge of 0.020 μC on each plate with a potential difference of 240 V. The plates are separated by 0.40 mm of air.
- A) What is the capacitance?
- B) What is the area of a single plate?
- C) At what voltage will the air between the plates ionize? (breakdown at 3.0 kV/mm)

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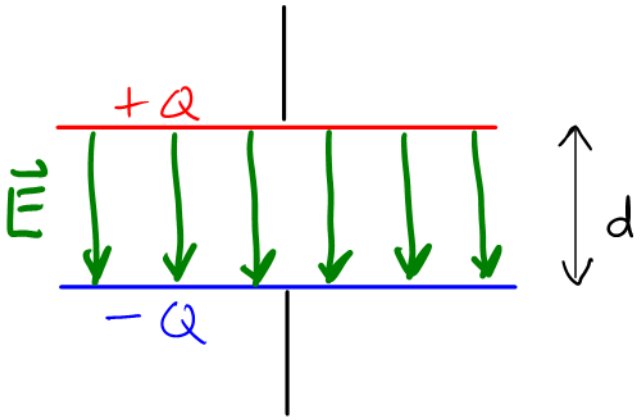
- Breakdown is characterized by a critical field strength. Since the plate separation is known, this can be translated into a critical potential difference (breakdown voltage for this capacitor).

Equations associated with ideas:

$$\Delta V_c = \frac{Q}{C}$$

$$C = \varepsilon_o \frac{A}{d}$$

$$\Delta V_c = E\,d$$



$$E_{\text{breakdown}}^{\text{air}} = \frac{3{,}000\ \text{V}}{\text{mm}}$$

depends on humidity

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- Calculate *C* from known voltage and charge.
- Determine plate area from calculated *C*.
- Use the known plate separation to translate the known breakdown field strength for air into the breakdown voltage for the given capacitor.

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- $\Delta V_{br} = E_{br} \cdot d = \frac{3{,}000\,V}{10^{-3}\,m} \cdot 0.40 \times 10^{-3}\,m = 1{,}200\,V = 1.2\,kV$

Real-life capacitors use dielectric material between thin foil. This allows them to be small (tiny d, small A). They are rated by their breakdown voltage. For these capacitors: exceeding ΔV_{br} destroys them. → Electrolytic capacitors may even explode.