L10 p1

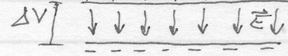
Capacitance

Consider 2 conductors separated by an insulator.

→ if attach to opposite terminals of a battery → become charged

- all $\vec{E}$ field lines originating on A terminate on B

2 charged || plates



→ uniform $\vec{E}$

→ for plates, a potential difference due to charges

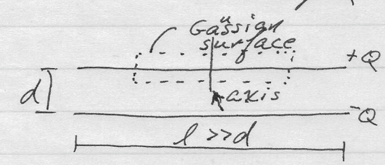
observation: $Q \propto \Delta V$
$= \text{const.}\ \Delta V$ — C

↳ depends on shape + separation of plates, + intervening material

$C \equiv Q/\Delta V$ => <u>capacitance</u> (units 'farad')

- amount of charge a capacitor can store per unit potential difference

L10 p2



Use Gauss's Law to calculate E-field

→ a cylinder surface with axis ⊥ to plates

$$\Phi_E = \Phi_E^{TOP} + \Phi_E^{SIDE} + \Phi_E^{BOTTOM}$$

→ top surface inside conductor
∴ no field flux

→ side (cylinder) has $\vec{A} \perp \vec{E}$ so
$\vec{E} \cdot \vec{A} = 0$ => no field flux

→ bottom surface $\vec{E} \parallel \vec{A}$

$$\Phi_E = \vec{E}\cdot\vec{A} = EA = q_{in}/\epsilon_0$$

$$\Rightarrow \underline{E} = \frac{q_{in}}{\epsilon_0 A} = \boxed{\frac{\sigma}{\epsilon_0}} \qquad (q_{in} \le Q)$$

By substitution,

$$\Delta V = Ed \text{ (uniform E-field)} = \frac{Qd}{\epsilon_0 A}$$

→ total charge on plate (not only inside Gaussian surface)

Therefore

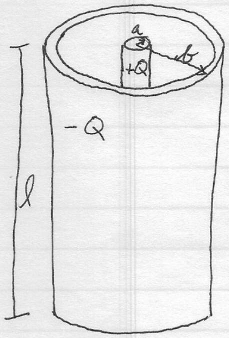
$$\underline{C} = Q/\Delta V = \frac{\cancel{Q}}{\cancel{Q}d/\epsilon_0 A} = \boxed{\frac{\epsilon_0 A}{d}}$$

↳ only geometry of plates involved

→ bigger plates: more Q & C

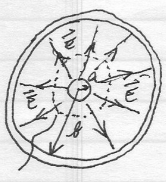
→ larger separation: less C

Cylindrical Capacitor



Two coaxial cylinders of radii a & b such that $b>a$. The cylinder length $l >> b$ so can ignore end or fringe effects.

Gauss's Law says outer cylinder doesn't contribute to E.



Gaussian surface

$\vec{E} \perp$ to axis and $\parallel$ to $\vec{r}$

From inner line (Ch. 24)

$$\boxed{E = 2k\lambda / r}$$

$$\underline{V_b - V_a} = -\int_a^b E_r\, dr = -2k\lambda \int_a^b \frac{dr}{r}$$

$$= \underline{-2k\lambda \ln(b/a)}$$

varies w/ΔV

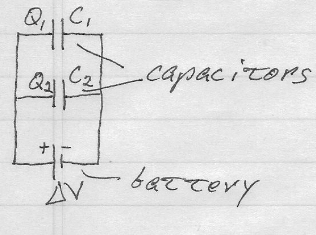
By substitution in $C = |Q|/|\Delta V|$

$$\underline{\underline{C}} = \frac{Q}{2k\lambda \ln(b/a)} = \frac{Q}{2k\, Q/l\, \ln(b/a)}$$

$$= \underline{l/(2k \ln(b/a))}$$

→ no λ, Q → only geometry

Combinations: Capacitors in ~~Ser~~ Parallel



In parallel configuration,

→ ΔV_1 across C_1 same as ΔV_2

→ charge flows when switch is closed

- stops when capacitors fully charged

$$Q_{TOTAL} = Q_1 + Q_2$$

Since $\Delta V = \Delta V_1 = \Delta V_2$,

$$Q_1 = C_1 \Delta V$$
$$Q_2 = C_2 \Delta V$$
$$Q_{TOT} = C_{effective} \Delta V$$

can think of an equivalent capacitor to C_1 & C_2 in parallel.

Thus,

$$C_{eff} \cancel{\Delta V} = C_1 \cancel{\Delta V} + C_2 \cancel{\Delta V}$$

$$\boxed{C_{eff} = C_1 + C_2}$$

Capacitors' capacitances sum when in parallel.