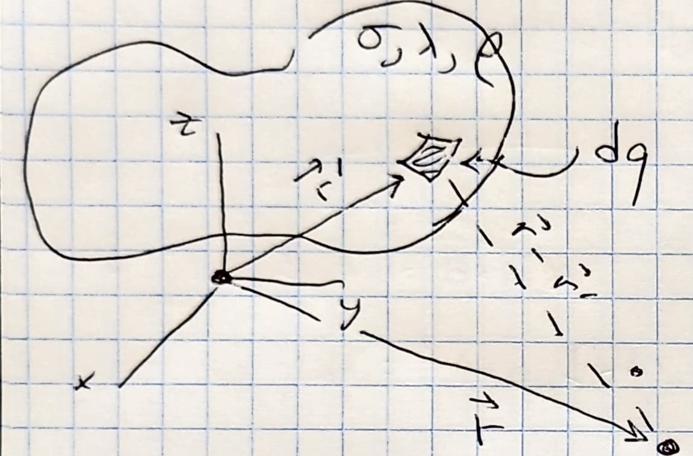
KEY TOOLS FOR YOUR EXAM

1 computing $\vec{E}(\vec{r})$ & $\phi(\vec{r})$



finding $E(\vec{r})$ & $\phi(r)$ due to charge densities ρ, σ, λ at $\vec{r}'$

the small field due to dq at $\vec{r}'$ measured at $\vec{r}$ is given by

$$\boxed{d\vec{E} = \frac{k\,dq}{(r-r')^2}}$$

where $dq = \rho\, dV$
or $dq = \sigma\, dA$
or $dq = \lambda\, dx$
for 3D, 2D, 1D objects

$$\boxed{d\phi = \frac{k\,dq}{|\vec{r}-\vec{r}'|}}$$

then integrate over the volume/surface of the object.

Ohm's Law

$$\vec{J} = \sigma \vec{E} = \frac{1}{\rho} \vec{E}$$

$\vec{J}$ is current density. this is charge/sec per AREA

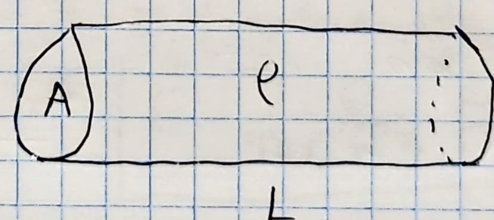
e.g. $[\vec{J}] = \frac{C}{s \cdot m^2}$ and $JA = I = \frac{\text{charge}}{\text{second}}$

σ is the "conductivity" & $\rho = \frac{1}{\sigma}$ is resistivity

$[\rho]$ = Ohm · meters

$R \equiv$ resistance depends on Geometry

e.g $R = \rho \frac{L}{A}$ for an object like

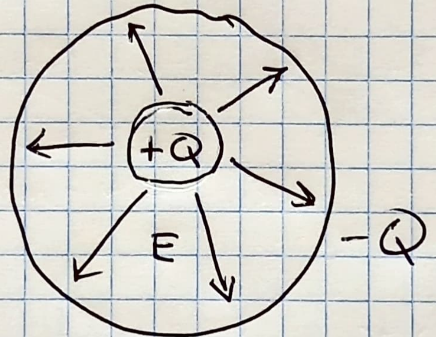


(3) potential difference

$$V = \phi(b) - \phi(a) = \int_a^b \vec{E} \cdot d\vec{\ell}$$

In electro-statics this integral is path-independent!
pick any path you'd like!

e.g. Pot diff b/w two spheres of radius a<b



1st the field is found by Gauss

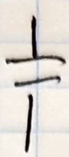
$$\int \vec{E} \cdot d\vec{A} = \frac{Q_{in}}{\varepsilon_0} = E\,4\pi r^2 = \frac{Q_{in}}{\varepsilon_0}$$

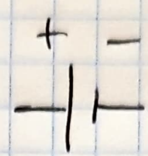
$$\Rightarrow \boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}}$$

Now $V = \int_a^b \vec{E} \cdot d\vec{\ell}$ choose radial path

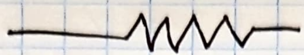
$$= \frac{Q}{4\pi\varepsilon_0}\int_a^b \frac{dr}{r^2} = \boxed{\frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{b} - \frac{1}{a}\right)}$$

circuits


capacitor



Battery

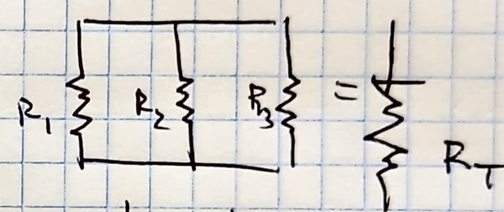

resistor

Ohm: $V = IR$

Series

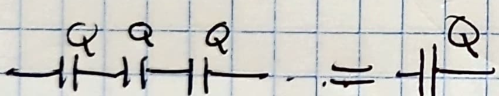
Res.  $R_T = \sum R_i$

Parallel



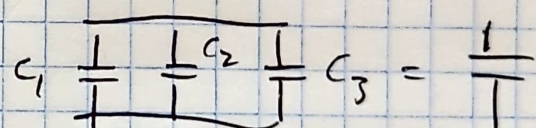
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

Caps



* Charge is the same on ALL plates! *

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$$



$$C_T = C_1 + C_2 + \ldots$$

~~Batt~~ RC circuits

the constant $\boxed{\tau = \frac{1}{RC}}$