

Electricity & Magnetism

Franken Practice
Session

- 1 - Dielectrics
- 2 - Biot-Savart
- 3 - Ampère
- 4 - Helmholtz
- 5 - dia-/paramagn. (linear)

(1) $\vec{E}$ in a material = ? $\vec{E}_{up}$, $\vec{B}_{dip}$
 $+q$ $-q$ } dipole $\vec{p} = q\vec{d}$ } $V_{dip} = ()$
 $\vec{E} = \vec{p} / \text{Vol}$ } $V = \int ()$
 material volume



(2) given $\vec{D}$, find $\vec{E} = ?$

$$V = \frac{1}{4\pi\epsilon_0} \oint \vec{D} \cdot \hat{n} da + \frac{1}{4\pi\epsilon_0} \int \frac{(-\nabla \cdot \vec{D})}{r} dr$$

pot of surface ch. pot of vol ch.
 $\phi = \vec{D} \cdot \hat{n} = \hat{n} da$ $\phi = -\nabla \cdot \vec{D}$

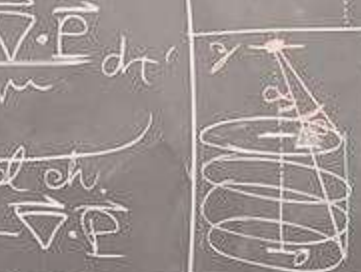
$$\vec{D} = \epsilon_0 \vec{E} + \vec{P}$$

$$= \epsilon_0 (1 + \chi_e) \vec{E}$$

$$= \epsilon \vec{E}$$

- 1 ignore material $\rightarrow$ Vacuum
- 2 calculate $\vec{D}$ (using Gauss)
- 3 $\vec{E} = (1/\epsilon) \vec{D}$ net field in material

(3) spherical cylindrical
 $\vec{B}(\vec{r}) = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l} \times \hat{r}}{r^2}$ curly
 $3 \vec{B} = ?$ wire(s) $\vec{B} = ?$

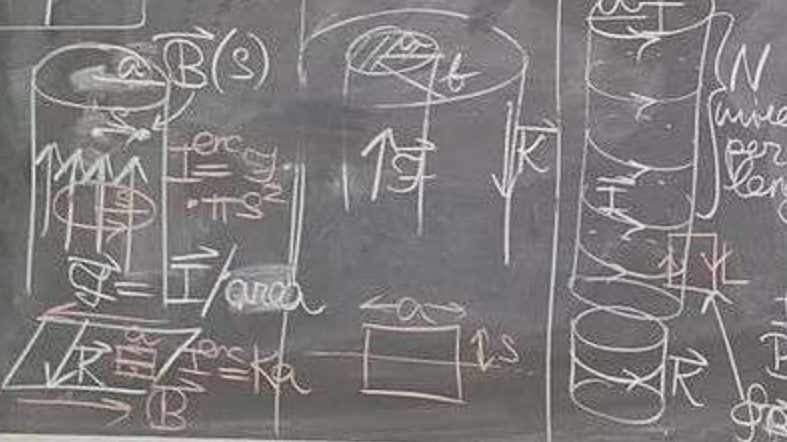


(4) given $\vec{E}_{ext}$ only from $\odot$ find $\vec{E}$ in material.

$$\vec{P} \propto \vec{E} \text{ [linear dielectric]}$$

$$\vec{P} = \epsilon_0 \chi_e \vec{E}$$

(5) $I_{enc} =$ all current passing through $\vec{I} \cdot \hat{n}$
 $I_{enc} = \int \vec{J} \cdot d\vec{a} = \int \vec{J} \cdot \hat{n} da$
 $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$



(6) Helmholtz
 any field $\vec{F} = -\nabla U + \nabla \times \vec{S}$
 $U(\vec{r}) = \frac{1}{4\pi} \int \frac{\nabla \cdot \vec{F}}{r} dr$
 $\vec{S}(\vec{r}) = \frac{1}{4\pi} \int \frac{\nabla \times \vec{F}}{r} dr$ curly
 $\vec{E}: \nabla \times \vec{E} = 0 \Rightarrow \vec{S}_E = 0$
 $\vec{B}: \nabla \cdot \vec{B} = 0 \Rightarrow U_B = 0$
 $\vec{B}$ conservative $\vec{E}$ curl-only
 $\vec{B} = \nabla \times \vec{A}$

for $\vec{B}$: $\vec{A}$ exists
 $\vec{B} = \nabla \times \vec{A}$
 $\vec{B}(s > a) = \text{const}$
 $\oint \vec{B} \cdot d\vec{l} = L B_{inside}(s)$

We have freedom
 $\vec{A} \rightarrow \vec{A} + \nabla \chi$
 $\vec{U} \rightarrow \vec{U} + \text{const}$ gauge

(7) $\vec{a} = \oint d\vec{a}$
 $\vec{a} = (\text{Area}) \hat{n}$
 $\vec{m} = I \vec{a}$
 ? given $\vec{M}$ find $\vec{B}$ 2nd loading
 $\vec{B} = \nabla \times \vec{M}$

1 find $\vec{K}_b$ $\vec{J}_b$ 2 calc $\vec{B}$ from Ampère
 ? given $\vec{B}_{ext}$ find $\vec{B}$ net
 $\vec{B} = \frac{\mu_0}{4\pi} \vec{H}$ $\vec{M} = \chi_m \vec{H}$
 $\vec{B} = \frac{\mu_0}{4\pi} \vec{H} + \mu_0 \vec{M}$

