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Instructor
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DAY 1

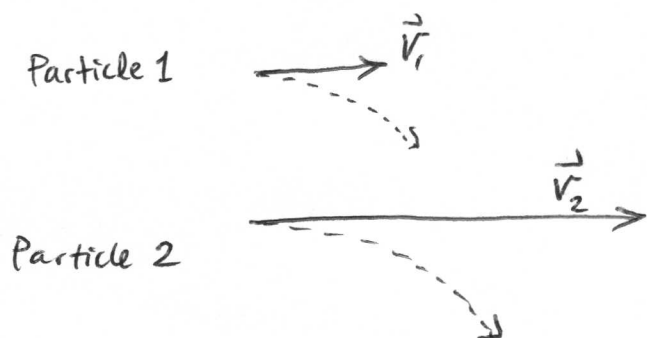
E&M II PH632

"Electricity and magnetism are not separate subjects, rather two aspects of a single subject."

To illustrate this point, consider that what one observer interprets as an electrical process, another may interpret as magnetic

For example $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ is true in every reference frame.

Observer 1 sees moving charges deflected downward with a force proportional to the ~~y~~ x-component of velocity



The observation is described by a \vec{B} -field pointing out of the page.


No \vec{E} -field.

(2)

Observer 2 moves along with particle 1.


In the reference frame of observer 2, particle 1 starts with no velocity. Yet particle 1 accelerates downward.

Particle 1



Observer 2 concludes there is an \vec{E} pointing downward (and a modified \vec{B} -field).

Particle 2



CONCLUSION: To create a theory that works in every reference frame, we will need both \vec{E} & \vec{B} fields.

Other reasons to study \vec{B} -fields

- Understand light (electromagnetic radiation)
- Build technology (electric motors
electric ~~was~~ generators
MRI
magnetic storage
⋮

(3)

Starting place

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

one of the four Maxwell's Eqns.

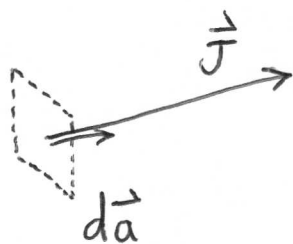
Consider the special case $\frac{\partial \vec{E}}{\partial t} = 0$.

i.e. $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$

If I am told $\vec{J}(\vec{r})$, I can use this diff. eqn to determine $\vec{B}(\vec{r})$.

THE VECTOR FIELD \vec{J} , CURRENT DENSITY

SI units for \vec{J} is $\frac{\text{Ampere}}{\text{m}^2}$. \vec{J} points in the direction of local current flow.



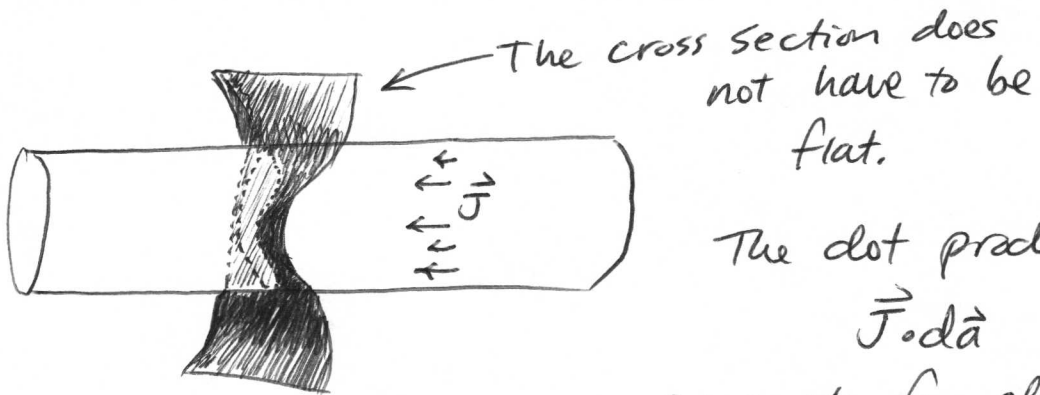
If $d\vec{a}$ is parallel to \vec{J} then current passing through the imaginary window of area da is

$J da$

(4)

The total current flowing down a wire is

$$I = \int_{\text{any cross sectional area}} \vec{J} \cdot d\vec{a}$$



The dot product $\vec{J} \cdot d\vec{a}$ accounts for elements of area ~~which~~ that aren't squared up with \vec{J} .