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- Which leads us to an alternate expression of Faraday's Law

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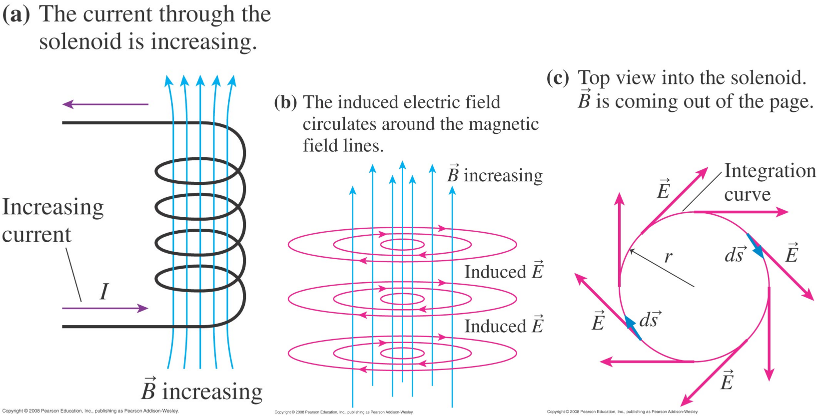
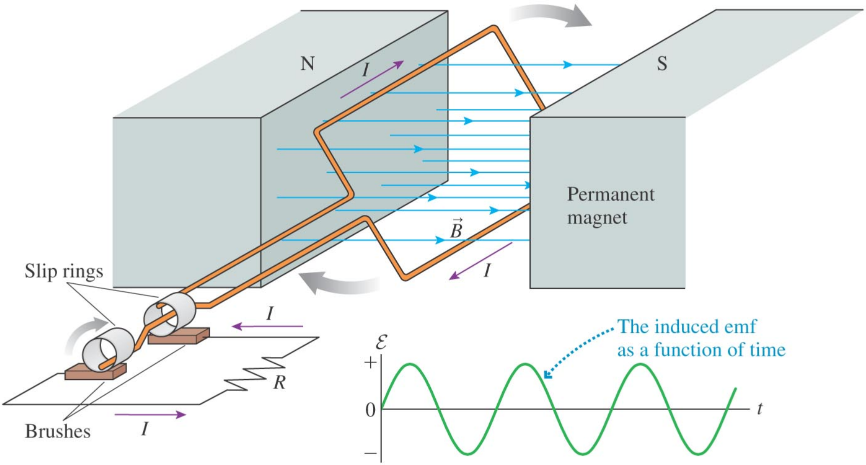


Induced Currents: Generators (34.7)



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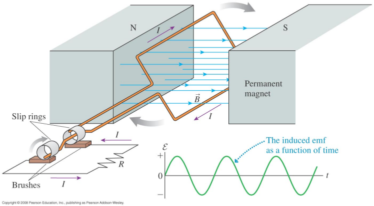

- The magnetic field and area are constant, but the rotation changes the effective area, so the flux is always changing. The flux is

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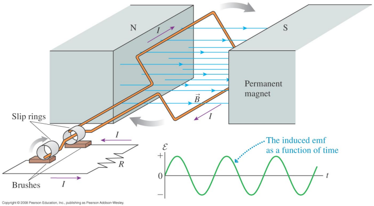

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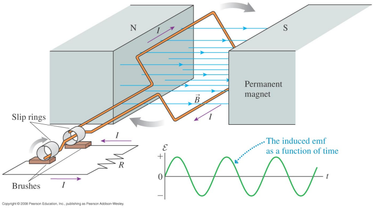

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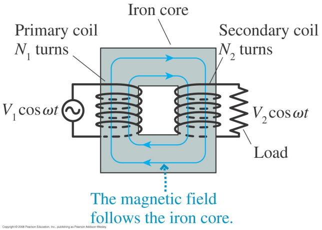

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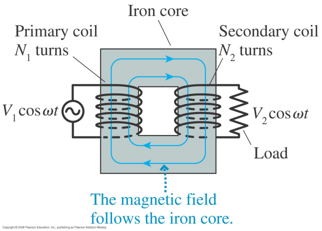

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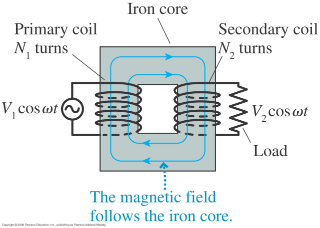
Transformers



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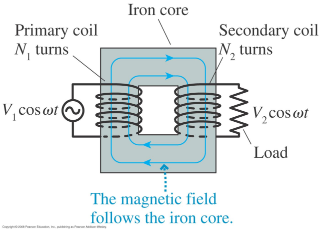

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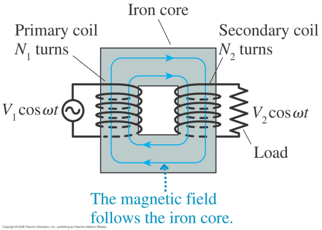

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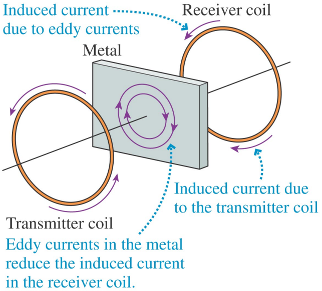
- Combining these gives

$$V_2 = \frac{N_2}{N_1} V_1$$

Metal Detectors



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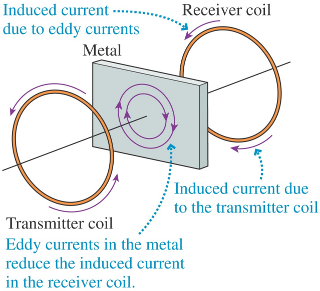

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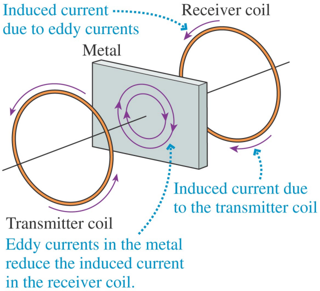

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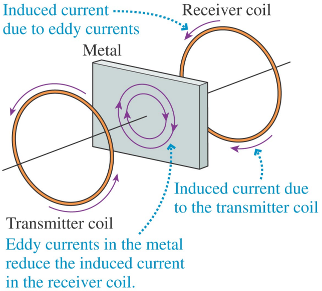

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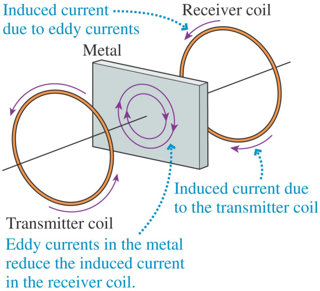

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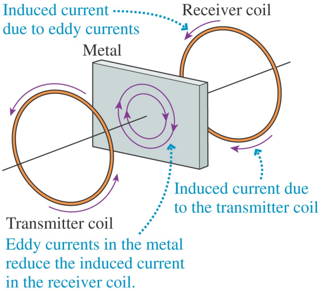

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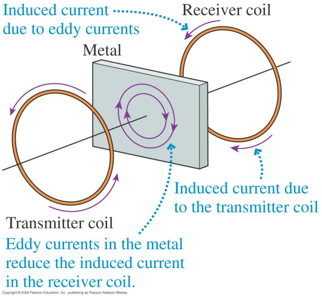

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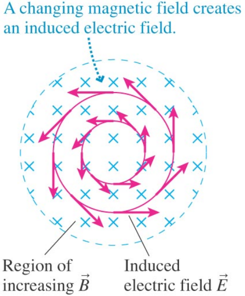
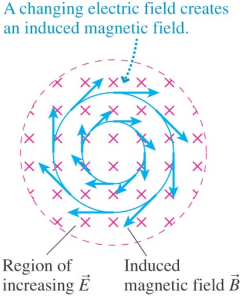
- An insulator does not allow eddy currents.

Maxwell's Theory of EM Waves





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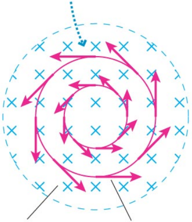

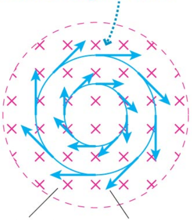

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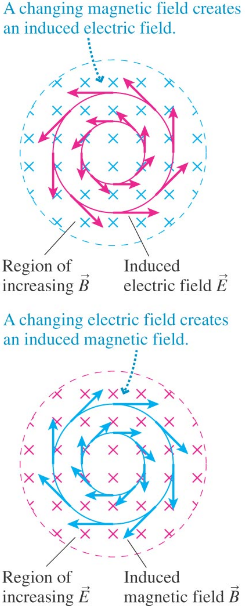

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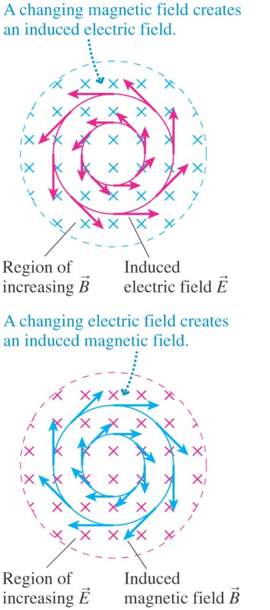

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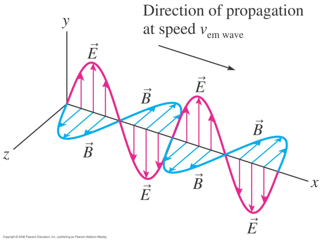
- The pictures are almost identical, except the direction of the electric fields are reversed.



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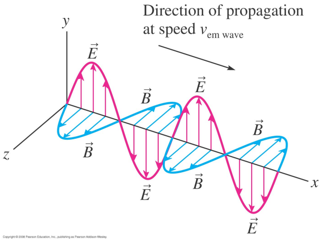

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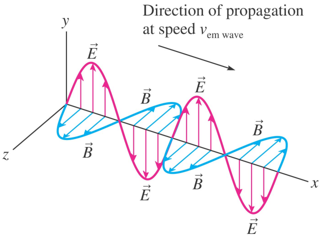

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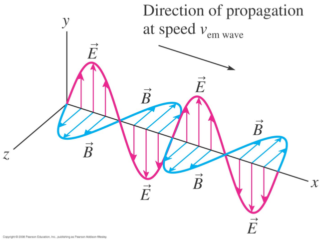

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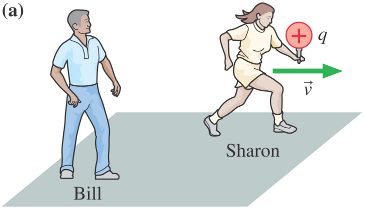
- He calculated the speed of such a wave to be

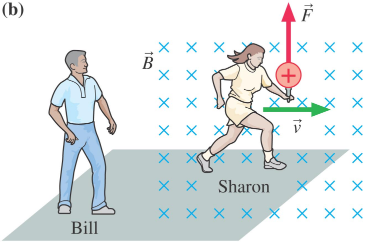
$$v = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = 3.00 \times 10^8 m/s$$

Light is an EM wave!!!!!

EM Waves Tidbits from Chapter 35



Charge q moves with velocity $\vec{v}$ relative to Bill.



Charge q moves through a magnetic field $\vec{B}$ established by Bill.

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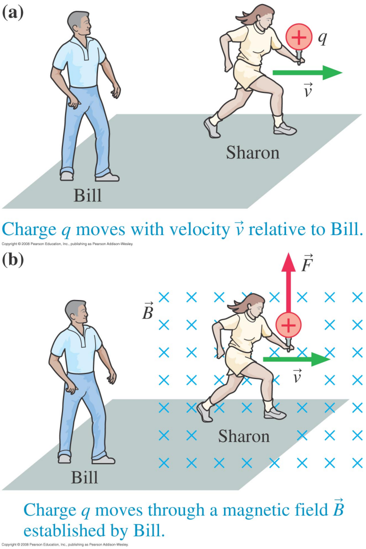
EM Waves Tidbits from Chapter 35



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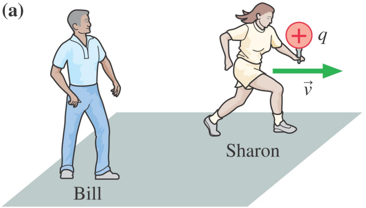
EM Waves Tidbits from Chapter 35



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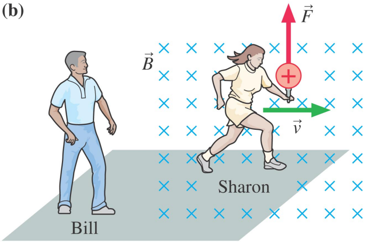

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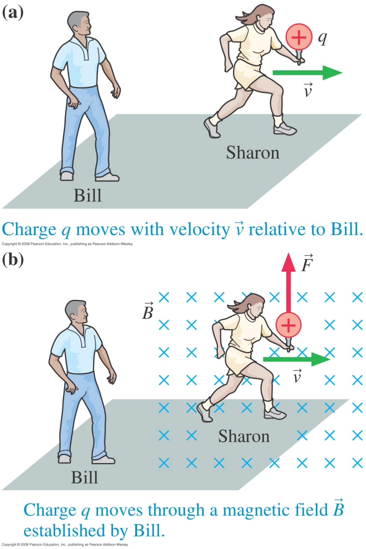

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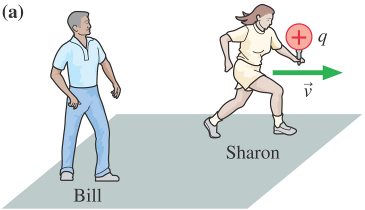
EM Waves Tidbits from Chapter 35



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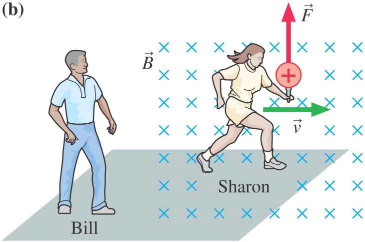

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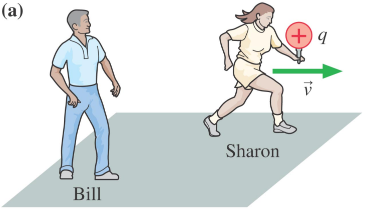
EM Waves Tidbits from Chapter 35

(a)



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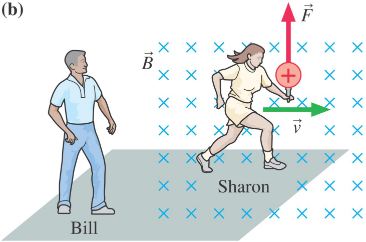

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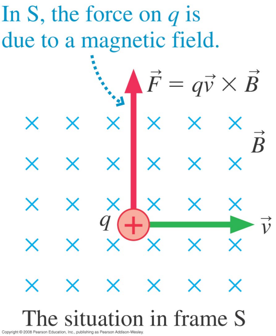
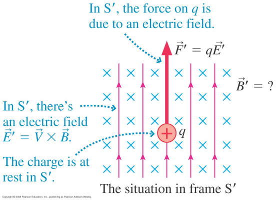
Transformation of Electric and Magnetic Fields





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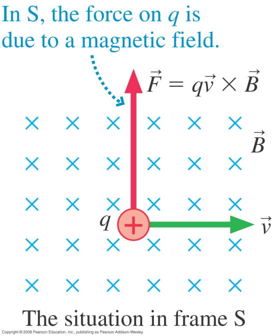

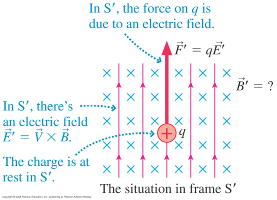

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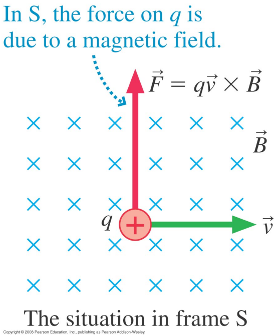
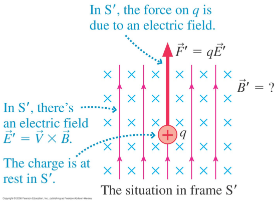
- Imagine "Bill" makes a region of uniform $\vec{B}$ but $\vec{E} = 0$ and shoots a particle of charge q through that region at velocity $\vec{v}$.

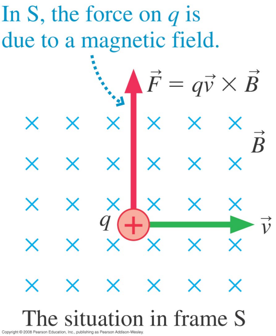
Transformation of Electric and Magnetic Fields

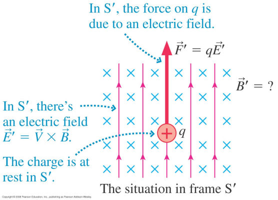




- We know something for sure: Experimenters in all inertial reference frames agree about a force acting on a particle.
- Imagine "Bill" makes a region of uniform $\vec{B}$ but $\vec{E} = 0$ and shoots a particle of charge q through that region at velocity $\vec{v}$.
- The total force on the particle from electric and magnetic fields will be

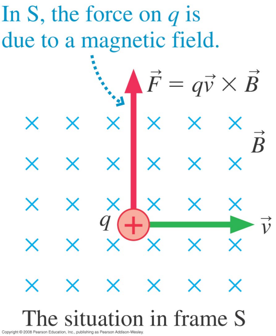
$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) = q\vec{v} \times \vec{B}$$

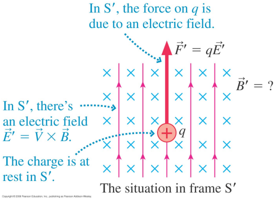




- Sharon is in a frame such that this particle is at rest. However, we agree that she **must** see an upwards force on the particle. How??

Transformation of Electric and Magnetic Fields





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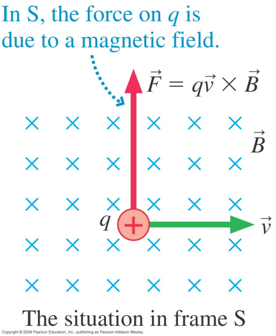
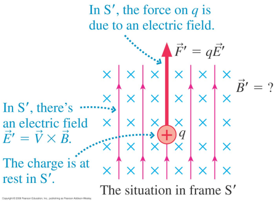
Transformation of Electric and Magnetic Fields





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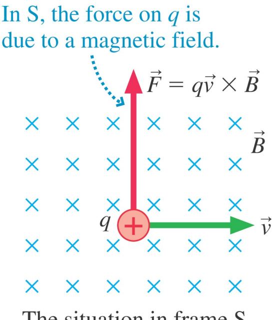
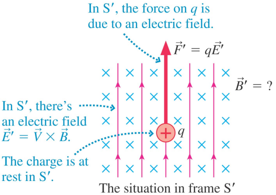
Transformation of Electric and Magnetic Fields





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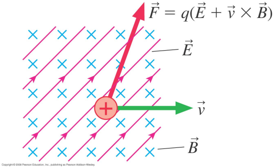
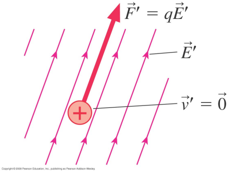
- Therefore, she must measure an electric field in her reference frame.
- Changing reference frames converts electric to magnetic fields or vice-versa!

(a) The electric and magnetic fields in frame S

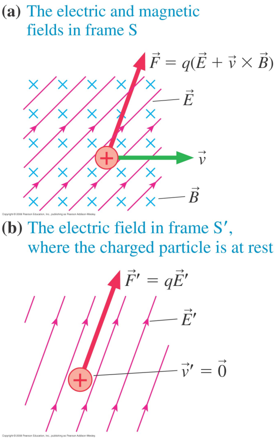


(b) The electric field in frame S′, where the charged particle is at rest



- In general, the total EM force on a charged particle is called the Lorentz Force

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$



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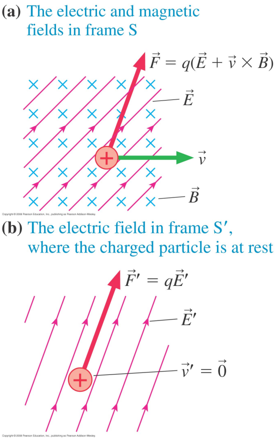
- The charge is at rest in frame S' moving at speed $\vec{V} = \vec{v}$, so in that frame the force is:

$$\vec{F}' = q\vec{E}'$$

Transformation of Electric and Magnetic Fields



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- Equating $\vec{F}$ with $\vec{F}'$ gives us the transformed electric field

$$\vec{E}' = \vec{E} + \vec{V} \times \vec{B}$$

- **There is a single EM field that changes its appearance from $\vec{E}$ to $\vec{B}$ for different observers.**

Transformation of Electric and Magnetic Fields

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Correspondence between $\vec{E}$ and $\vec{B}$

The Biot-Savart law for the magnetic field of a moving point charge is nothing other than the Coulomb electric field of a stationary point charge transformed into a moving reference frame!