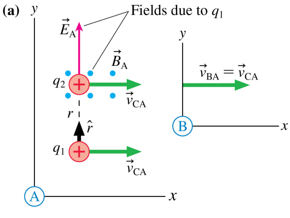
Filling out the Card

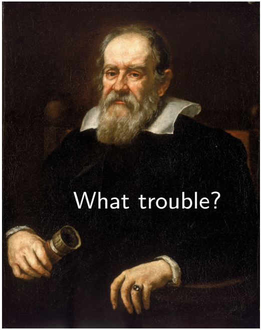
1. List which physics and math courses you have had especially Math Methods, Quantum Mechanics, Electricity and Magnetism.
2. Do you have experience with *Mathematica*?
3. What are your pronouns?

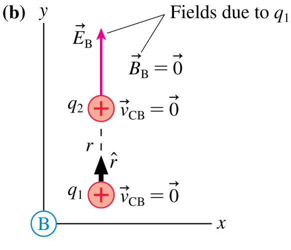
The Trouble With Galileo - 1 2

Consider Figure a. Two positive charges are moving side-by-side through frame A (also called the Home frame) with velocity $\vec{v}_{BA}$. What are the fields $\vec{E}_A$ and $\vec{B}_A$ of charge q_1 at the position of charge q_2 in frame A? In Figure b the B/Other frame is moving with the same velocity as the two charges. What are $\vec{E}_B$ and $\vec{B}_B$ at the position of q_2?



Fields seen in frame A





Fields seen in frame B

Physics is the same in all inertial reference frames (hopefully).

Galilean
$x' = x - vt$
$y' = y$
$z' = z$
$t' = t$
$v'_x = v_x - v_O$
$v'_y = v_y$
$v'_z = v_z$

primes refer to the frame moving with velocity v_O.

v_O - velocity of moving/Other/B frame.

v_i - i^{th} component of the velocity in the stationary/Home/A frame.

v'_i - i^{th} component of the velocity in the moving/Other/B frame.

Galilean
$x' = x - vt$
$v'_x = v_x - v_O$ $v'_y = v_y$ $v'_z = v_z$

Are Newton's Laws consistent with the Galilean transformations?

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Galilean
$x' = x - vt$

Are Newton's Laws consistent with the Galilean transformations?

Yes! The laws of physics are the same in all inertial frames.

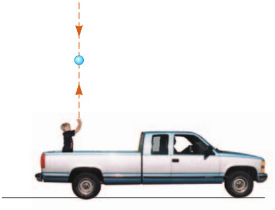
primes refer to the frame moving with velocity v_O.

v_O - velocity of moving/Other/B frame.

v_i - i^{th} component of the velocity in the stationary/Home/A frame.

v_i' - i^{th} component of the velocity in the moving/Other/B frame.

What changes in the trajectory of a tossed ball between the Home frame and the Other frame?



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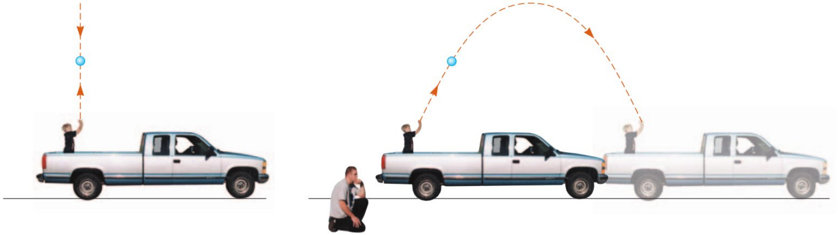

Galilean Relativity Example

A person who can swim at a speed c in still water is swimming in a river with a current of speed v_O where $c > v_O$. Suppose the person swims upstream a distance L and returns to the starting point. What is the time for this round trip? Compare this with the time it takes to swim the same distance L across the river and back. Note: The swimmer returns to the same point each time.

Ira Gershenhorn swims the Hudson River near 104th St in New York City (NYT 7/11/2018).

Galilean Transformation
$x' = x - vt$
$y' = y$
$z' = z$
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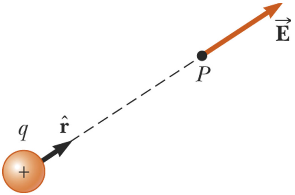
Coulomb's Law

$$d\vec{E} = k_e \frac{dq\hat{r}}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{dq\hat{r}}{r^2}$$



Apply GT to Electric and Magnetic Fields - 1

Coulomb's Law

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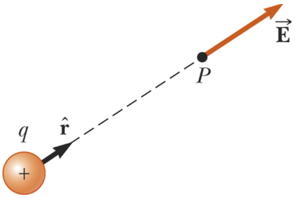
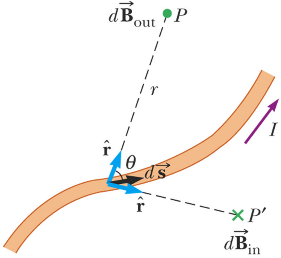


Biot-Savart Law

$$d\vec{B} = k_m \frac{Id\vec{s}\times\hat{r}}{r^2} = \frac{\mu_0}{4\pi}\frac{Id\vec{s}\times\hat{r}}{r^2}$$
$$= k_m \frac{q\vec{v}\times\hat{r}}{r^2} = \frac{\mu_0}{4\pi}\frac{dq\,\vec{v}\times\hat{r}}{r^2}$$



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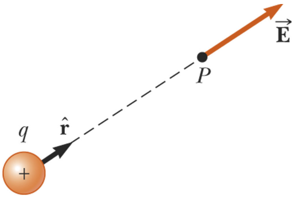

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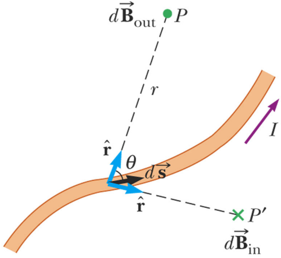
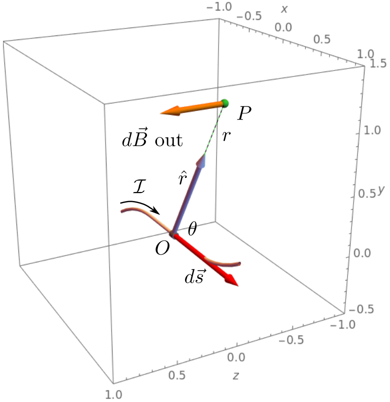
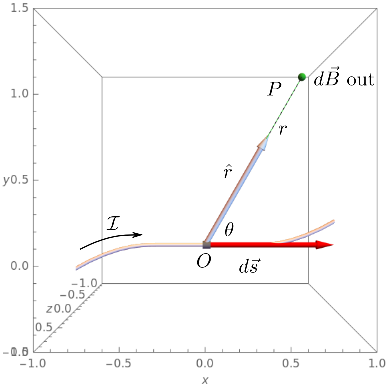


Electromagnetic Force Law

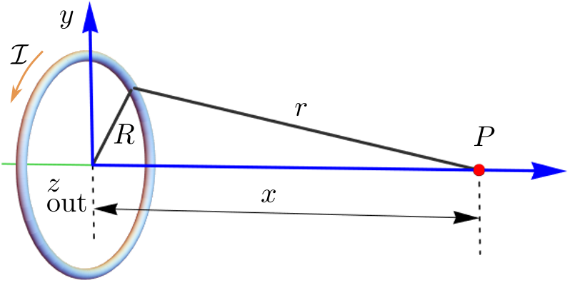
$$\vec{F} = q\left(\vec{E} + \vec{v}\times\vec{B}\right)$$

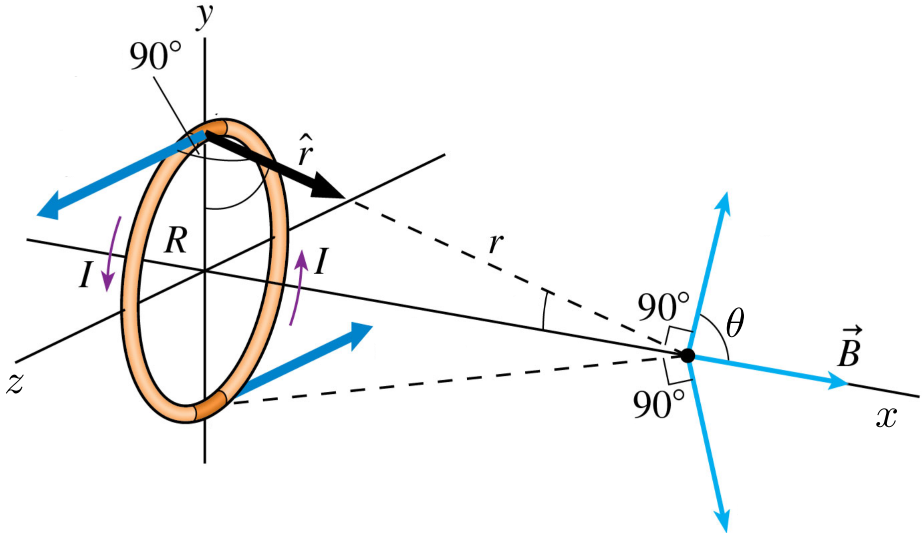
The figures show two views of a segment of a current. What is the magnetic field $d\vec{B}$ at the point P due to the infinitesimal chunk of current at O in terms of the current $\mathcal{I}$, $d\vec{s}$, r, and the angle θ?





(1) A ring of radius R as shown in the figure below has a current $\mathcal{I}$. Calculate the magnetic field $\vec{B}$ along the axis of the ring at a point lying a distance x from the center of the ring. Get your answer in terms of R, x, $\mathcal{I}$. (2) In Neils Bohr's 1913 model of the hydrogen atom an electron circles the proton at a distance $r = 5.29 \times 10^{-11}$ m with a speed $v = 2.19 \times 10^6$ m/s. What is the magnetic field at the position of the proton created by the electron's orbit?

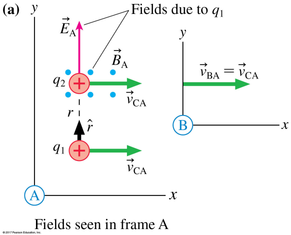


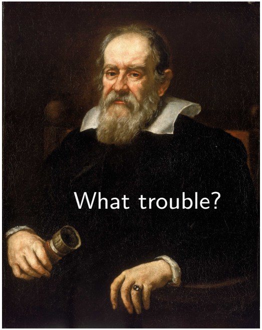


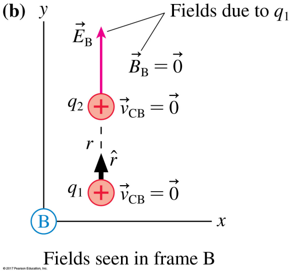
y
90°
r̂
R
I
I
r
90°
θ
B⃗
90°
z
x

The Trouble With Galileo - 3

Consider Figure a. Two positive charges move side-by-side through frame A (the Home frame) with velocity $\vec{v}_{BA}$. What are the fields $\vec{E}_A$ and $\vec{B}_A$ of charge q_1 at the position of charge q_2 in frame A? In Figure b the B/Other frame moves with the same velocity as the two charges. What are $\vec{E}_B$ and $\vec{B}_B$ at the position of q_2?







$$\vec{E}_B = \vec{E}_A + \vec{v}_{BA} \times \vec{B}_A$$

$$\vec{B}_B = \vec{B}_A - \mu_0\epsilon_0\vec{v}_{BA} \times \vec{E}_A$$

$$\mu_0\epsilon_0 = \frac{1}{c^2}$$

The vector $\vec{v}_{BA}$ is the velocity of the Other frame.

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