Thursday, 7 Feb

brought to you by the letters ELECTRIC AND MAGNETIC FIELDS

pitchers and catchers report in 6 days

AC/DC week (get it?)

housekeeping

MasteringAstronomy! Free. Go there & register:

Course ID: MABROCK41459

Access code: WSSPCT-BLIDA-INANE-TOGUE-RIGOT-UNRWA

free e-text, *The Cosmic Perspective*

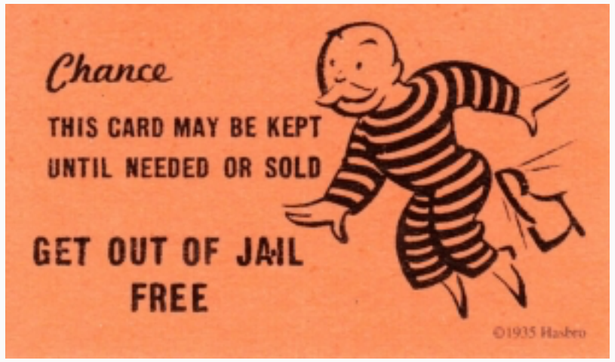
reading assignments and homework, mixed with Mastering Physics

During Part 1:

you're doing a great job keeping up!

I sure hope ~~you're keeping u~~p

amnesty



I will re-open the closing dates for all of the LON-CAPA reading questions for a brief window-of-reprieve

Saturday, February 9 midnight until Thursday, February 14 midnight

February 2019

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
27	28	29	30	31	1	2
		yadda yadda yadda				HW2
3	4	5	6	7	8	9
		lessons 10,11,12		lesson 13	HW2 due	HW3
10	11	12	13	14	15	16
		lecture		lecture	HW3 due	HW4
17	18	19	20	21	22	23
		lecture		lecture	HW4 due	HW5
24	25	26	27	28	1	2
←	midterm?	→ lecture		lecture	HW5 due	

Eastern Time Time Zone

quiz

but let’s look through the packet though

figures 3-8 we’ll do together

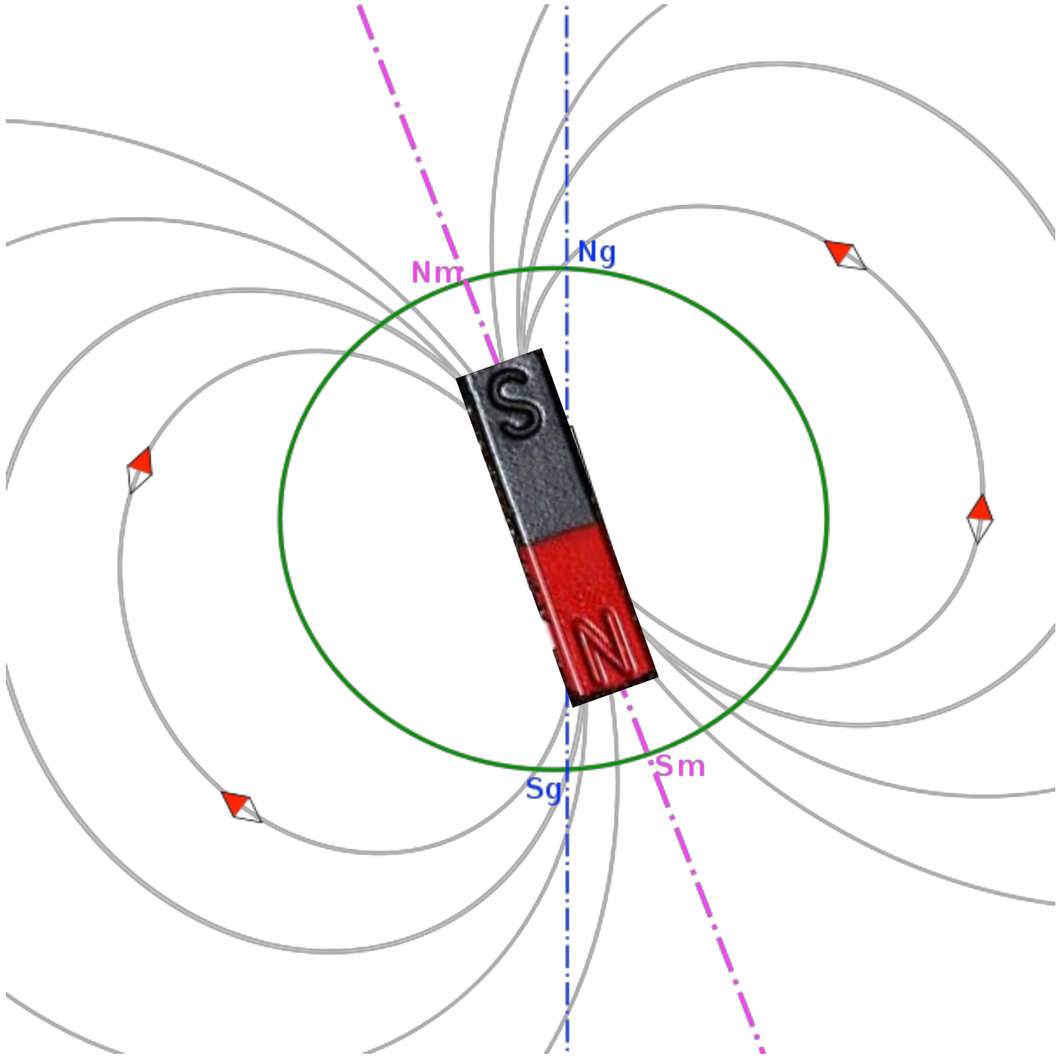
the rest is for you in groups, as per normal

Earth’s magnetic field

20-60 micro-T

enough to protect us from solar wind particles

reason we have auroras

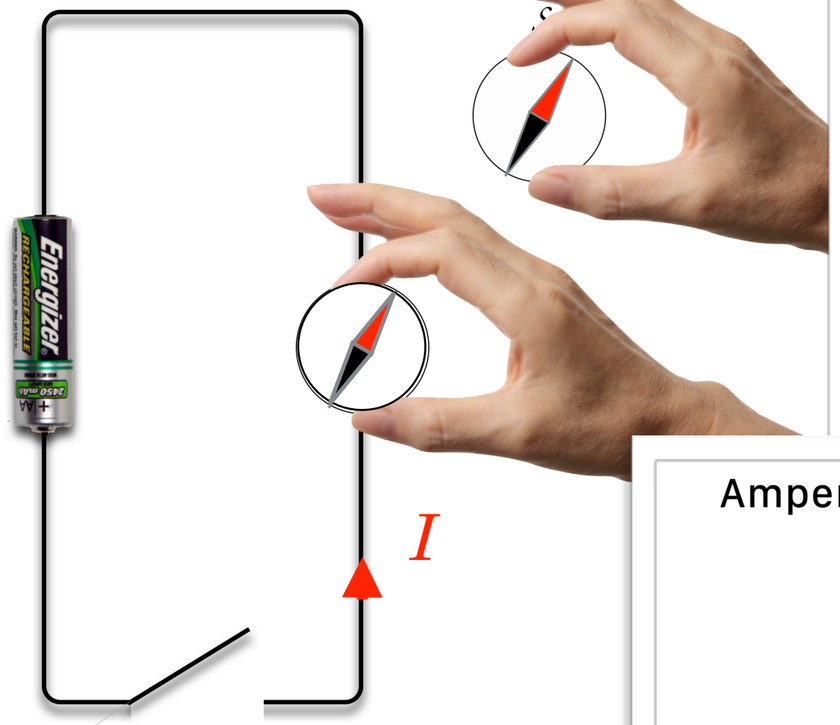


electricity and magnetism

we should all have lectures like this

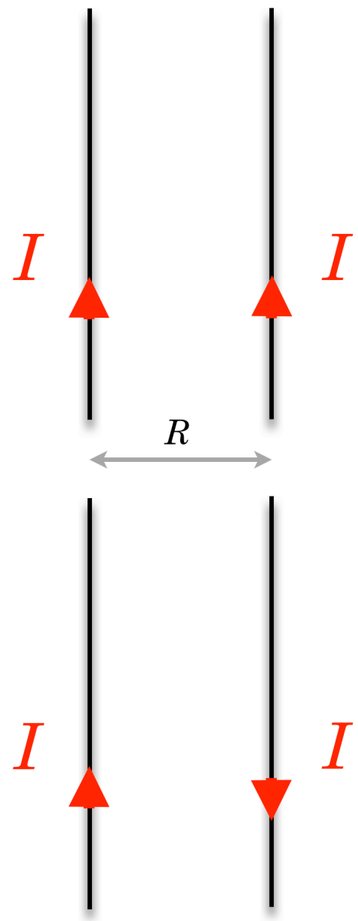
Hans Christian Oersted

April 21, 1820



Ampere's Law

forces between wires carrying current

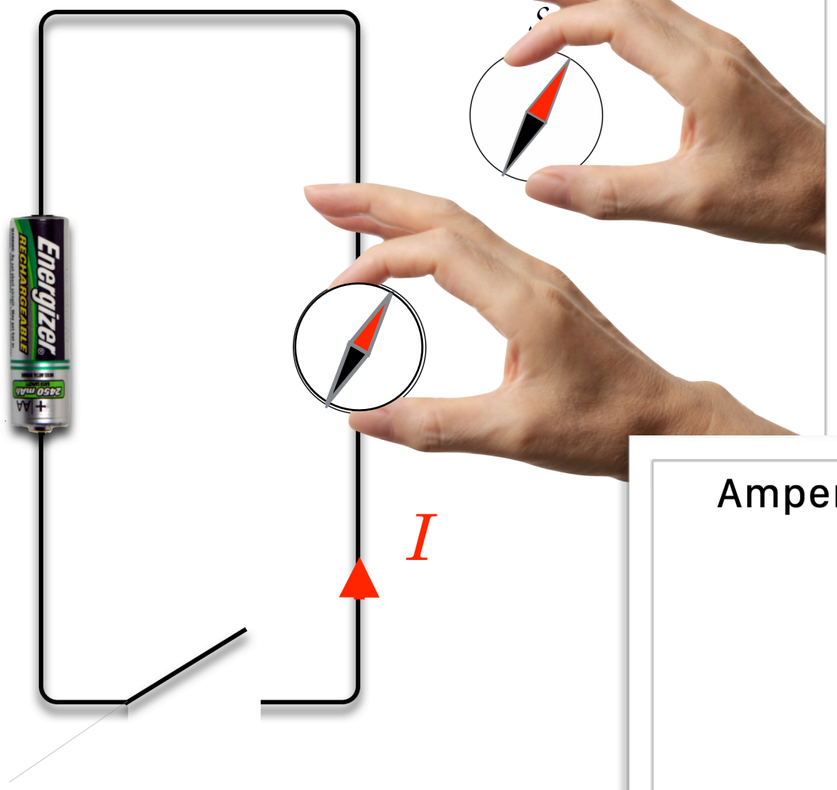


$$F \sim \frac{I_L I_R}{R}$$

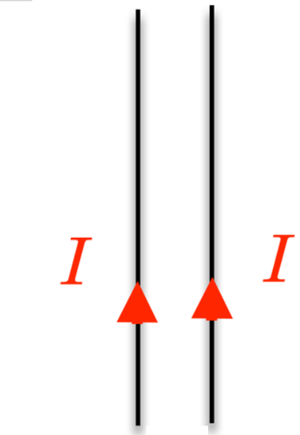
we should all have lectures like this

Hans Christian Oersted

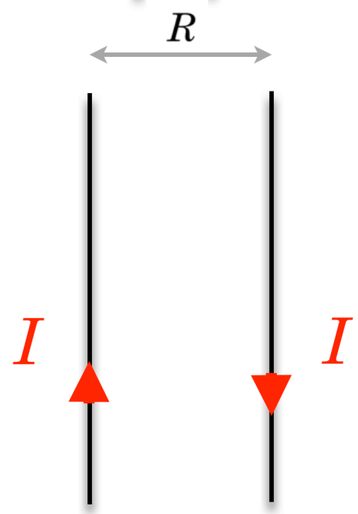
April 21, 1820



Ampere's Law



forces between wires carrying current



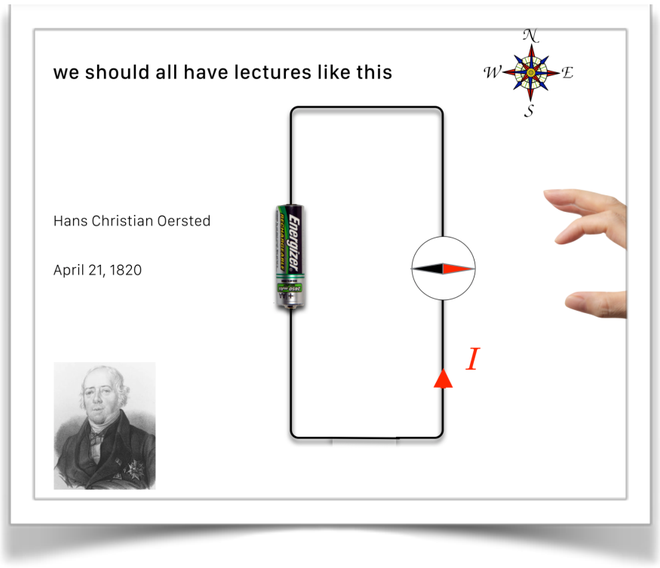
$$F \sim \frac{I_L I_R}{R}$$

You might want to think about this:

If currents cause magnetism

shouldn’t magnetism create currents?

there’s a story there.

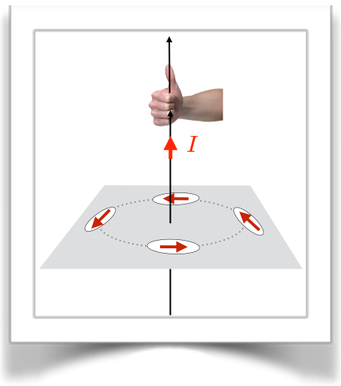


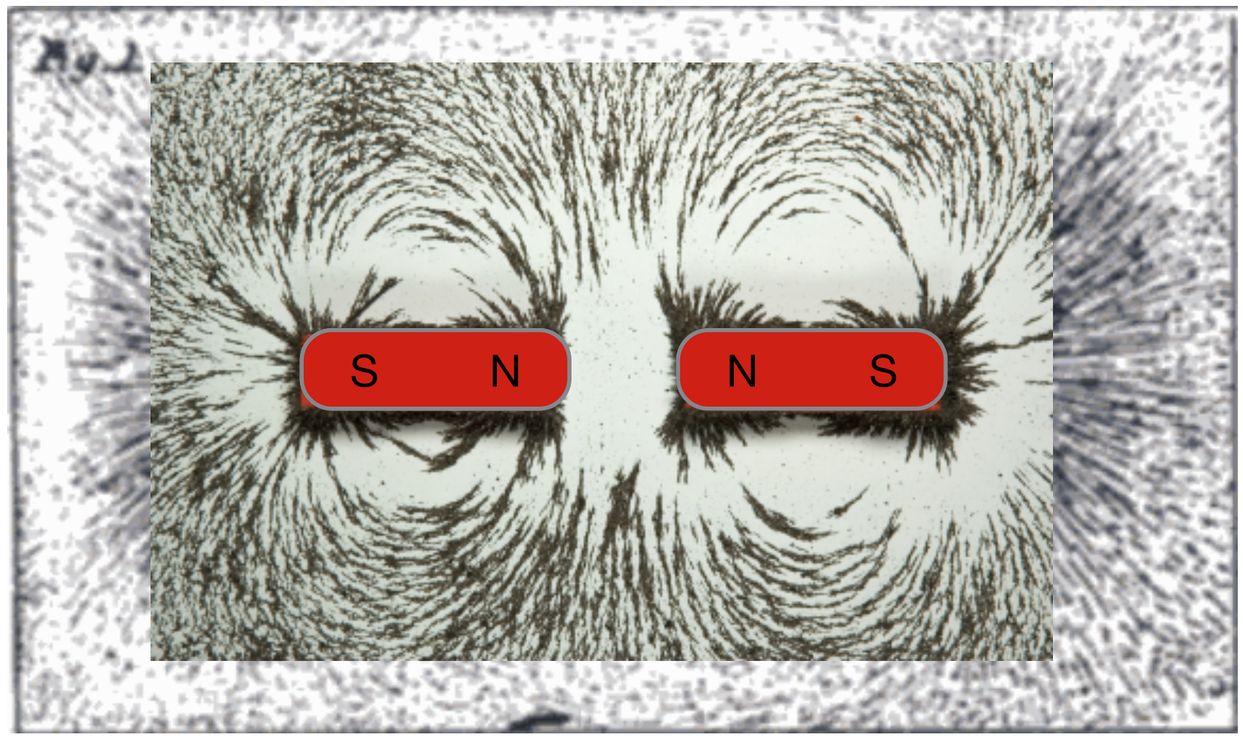
important

when magnetic lines of force **change in time**

a current flows: "**Faraday's Law**"

Faraday saw things





that weren't there for most

He saw:

"**lines of force**" exerting a physical force on little bits of iron

worse...

circular "lines of force" when currents were involved

Faraday's "model"

the lines of force were real features of space

he called this feature of space a "**field**"

"action at a distance"? no!

the field idea

“Action at a Distance”

a no-no

What about Electrostatic Forces?

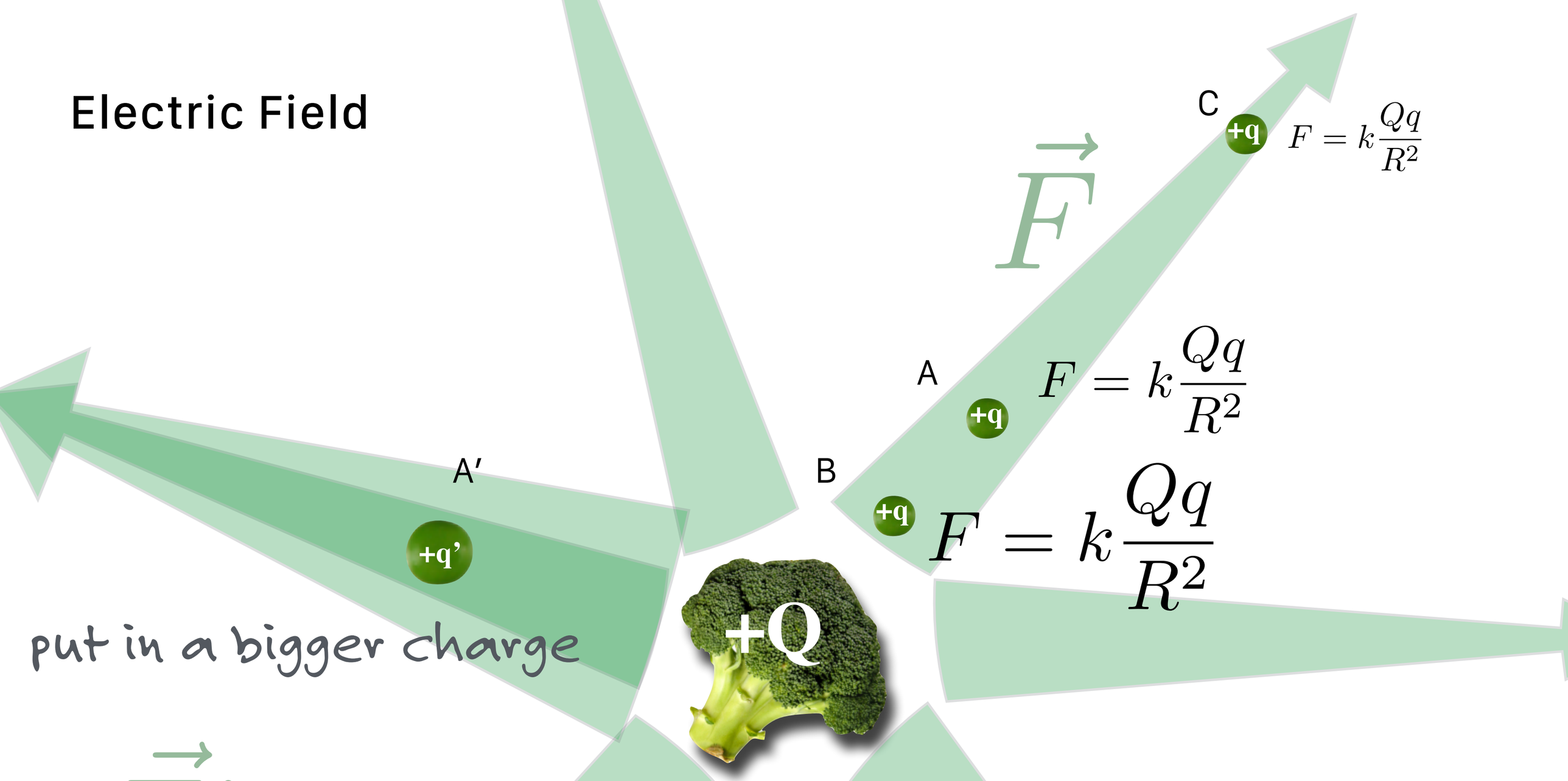
understanding a field

it's tough

it has a quantum mechanical explanation

meaning that classical explanations leave one gasping and uncertain

Electric Field



put in a bigger charge

$\vec{F}'$ would be bigger at A'
than at A

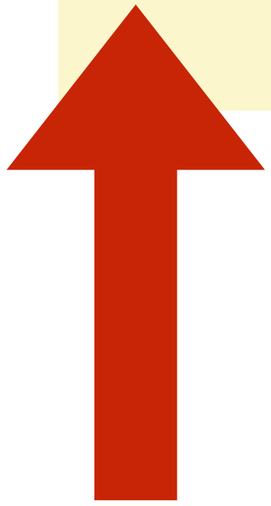
the electric force

depends on both charges

$$F = k\frac{Q}{R^2}(q)$$

depends only on Q

$$E = k\frac{Q}{R^2}$$

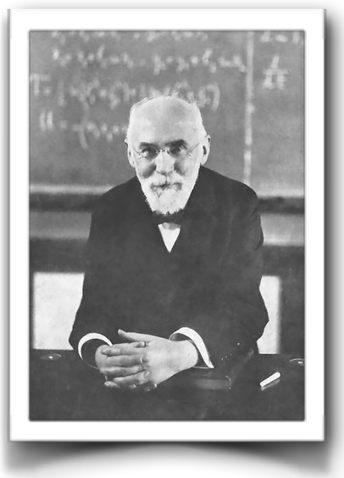


called the Electric Field for a point charge, Q

1/2 of "Lorentz Force"

Forces due to Electric Fields:

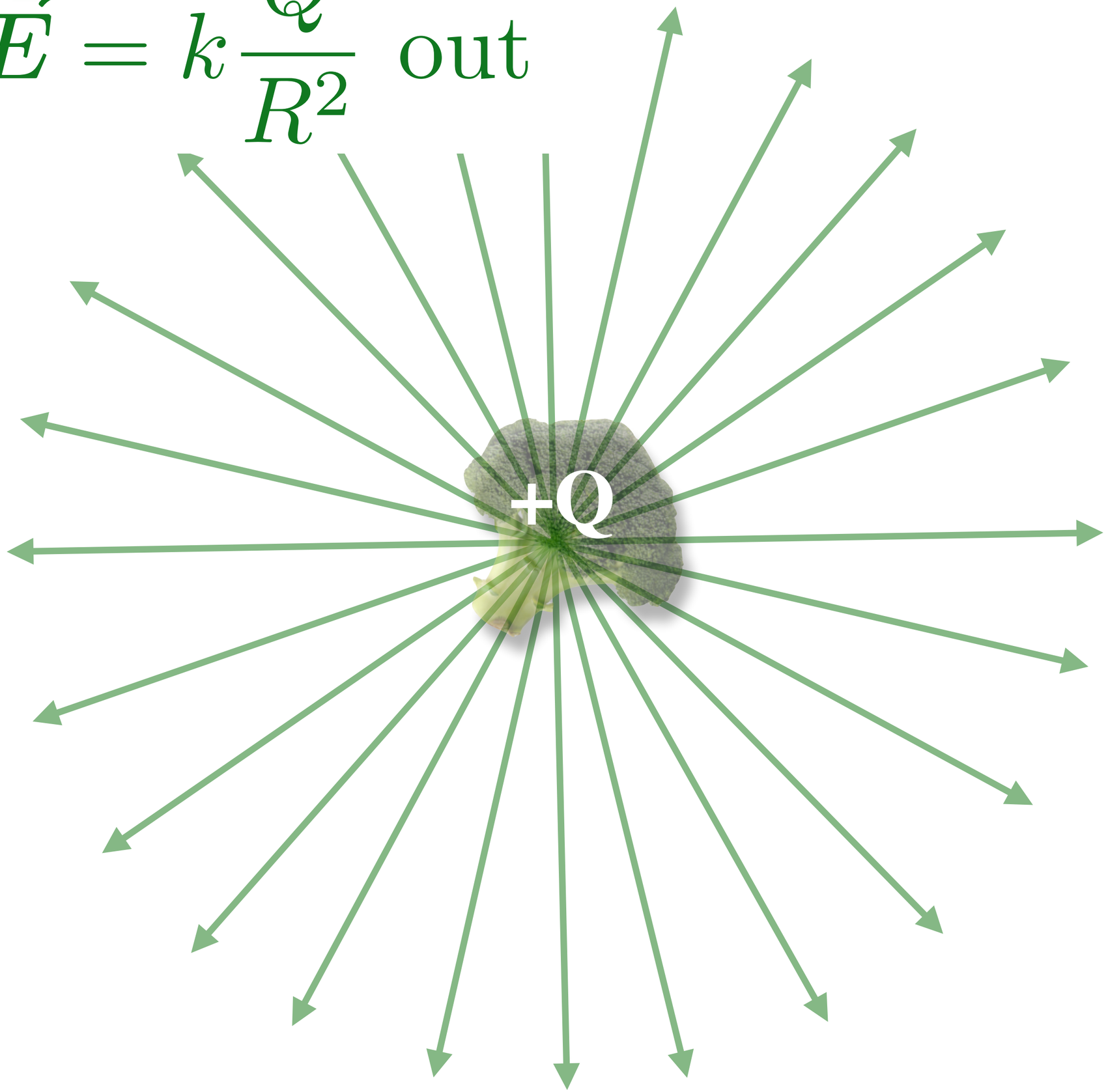
$$\vec{F} = \vec{E}q$$



the Electric Field

for a point, **POSITIVE** charge

$$\vec{E} = k\frac{Q}{R^2} \text{ out}$$



the field is the "mover" $F = Eq$

think of it as the cause

and also an effect

and the effect

and a cause

You might want to remember this:

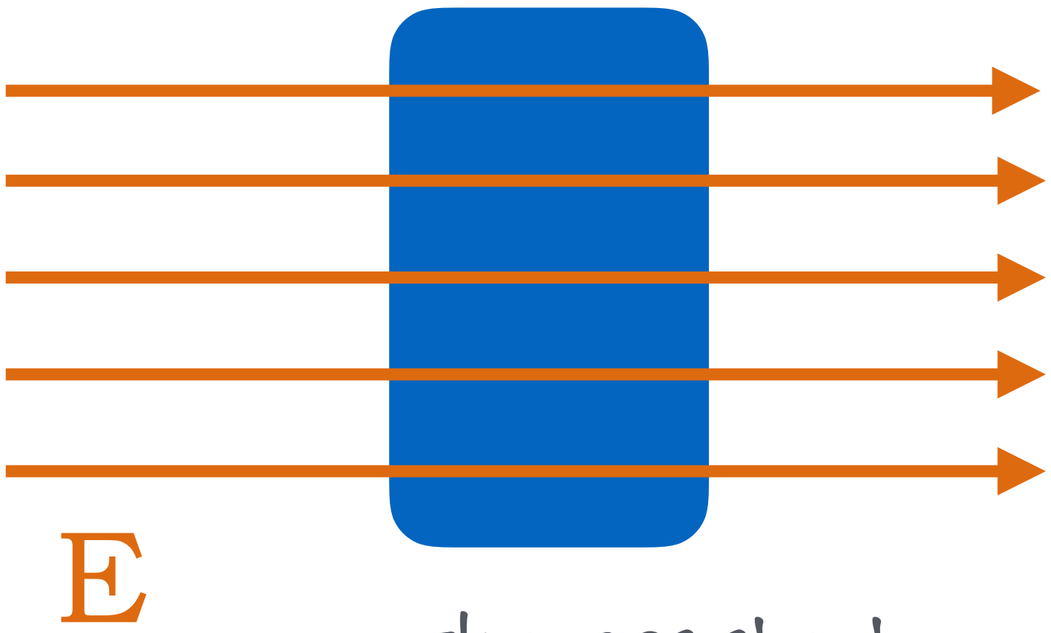
the Field is a thing.

there is no action at a distance

Electric fields apply forces to electric charges

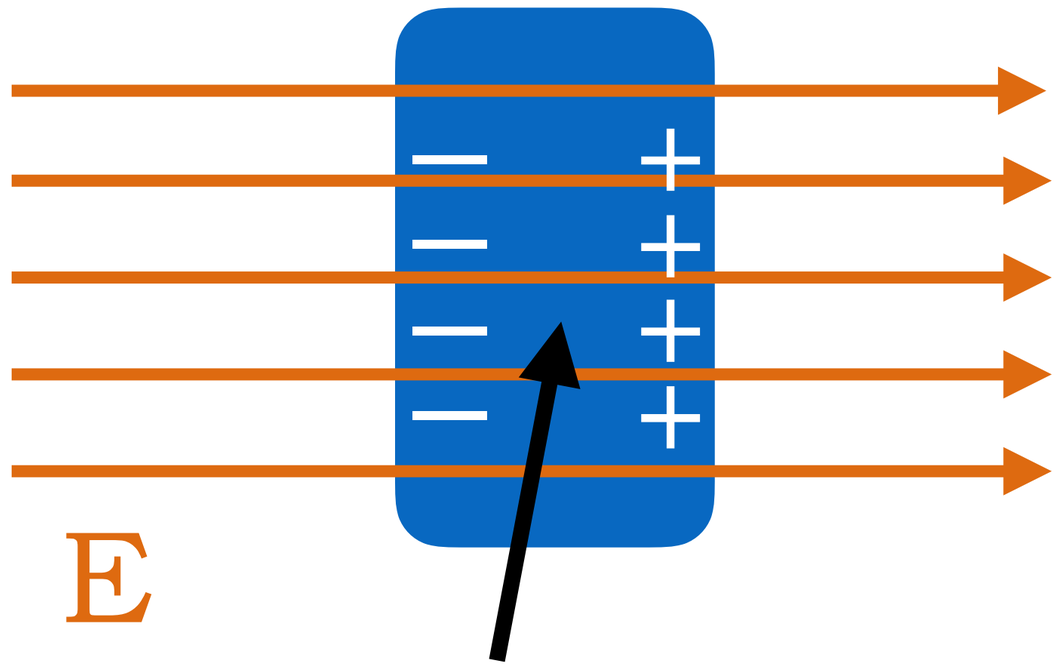
$$\vec{F} = \vec{E}q$$

chunk of metal

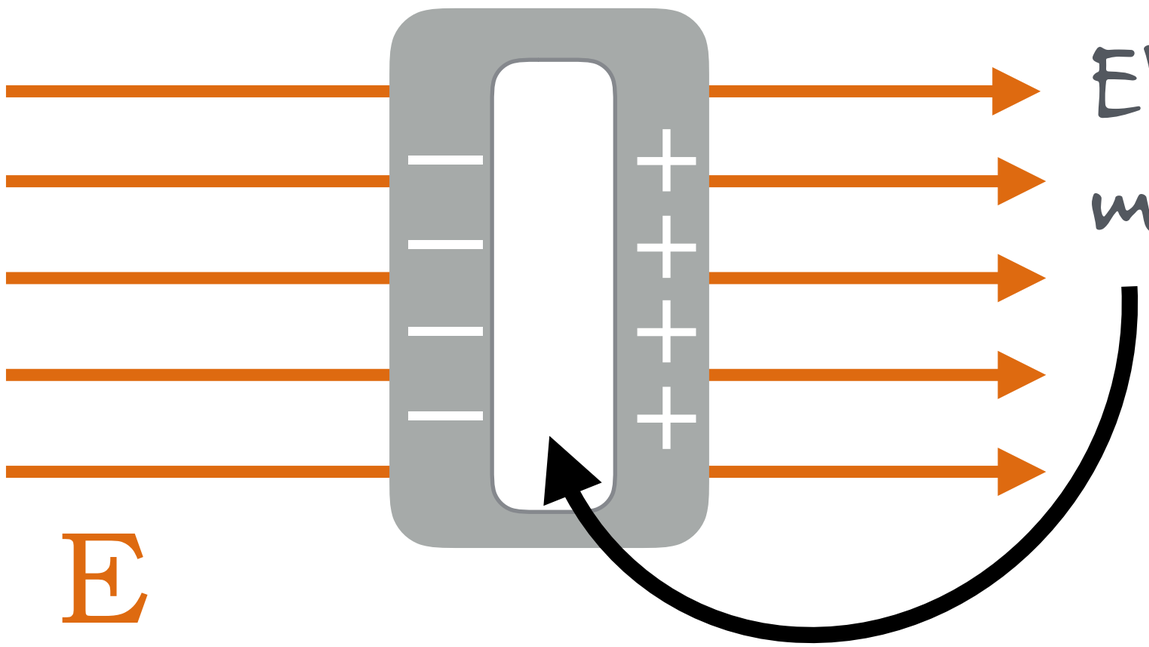


charges start rearranging themselves

chunk of metal



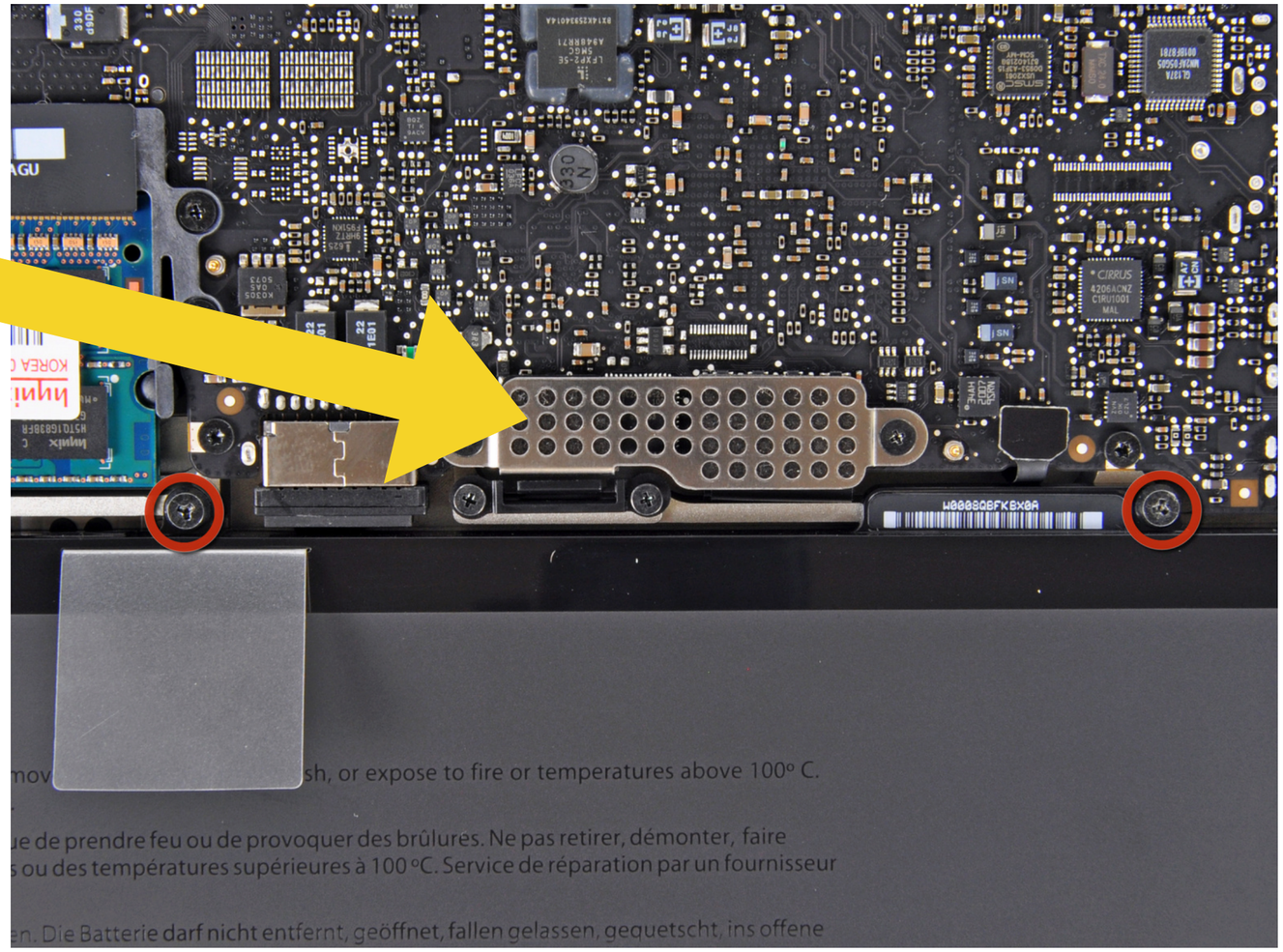
charges start rearranging themselves to make E=0 inside



Electric fields inside a metal enclosure are zero

Called a Faraday Cage

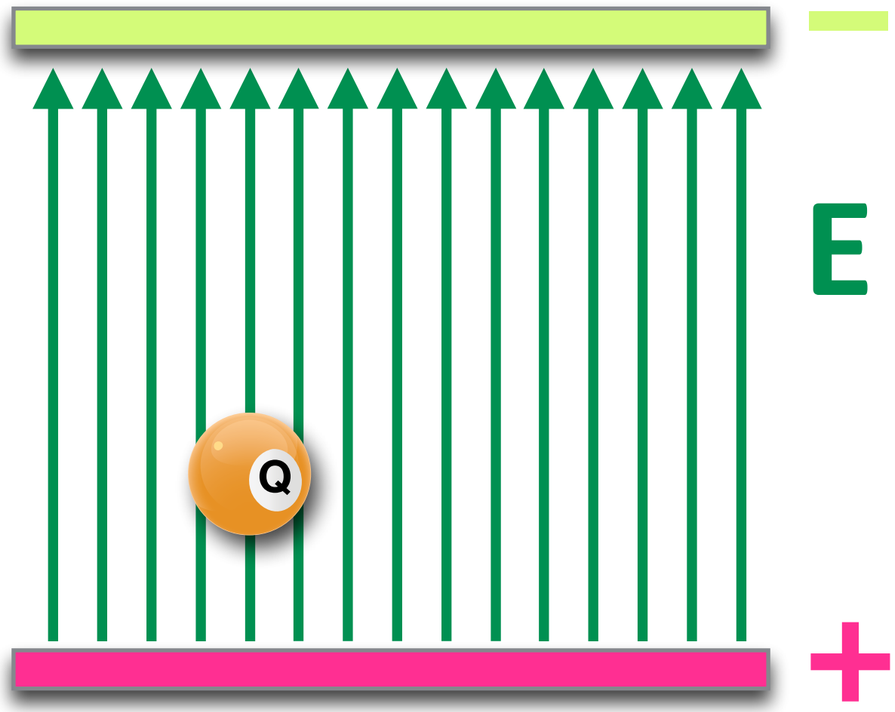
"EMI"* shield inside my macbook pro

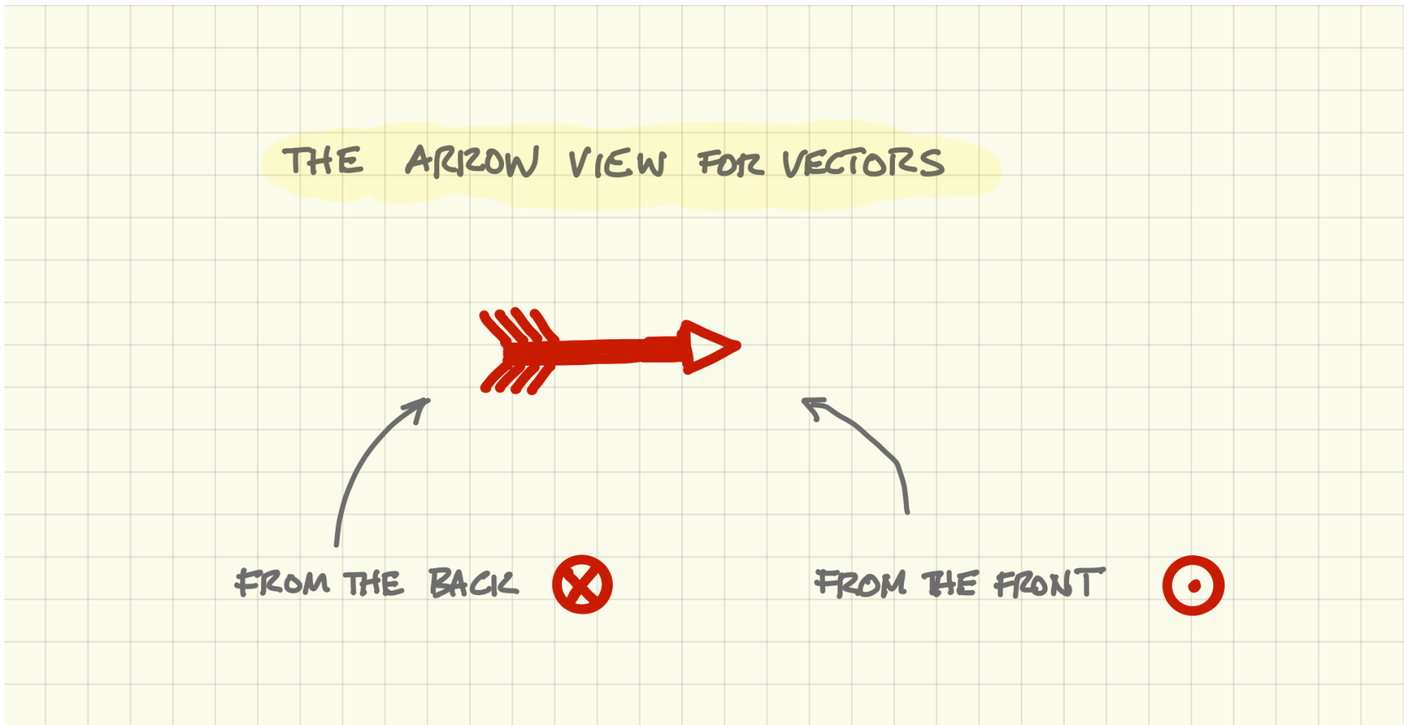


*ElectroMagnetic Interference

field potential energy

Q **feels a force,**

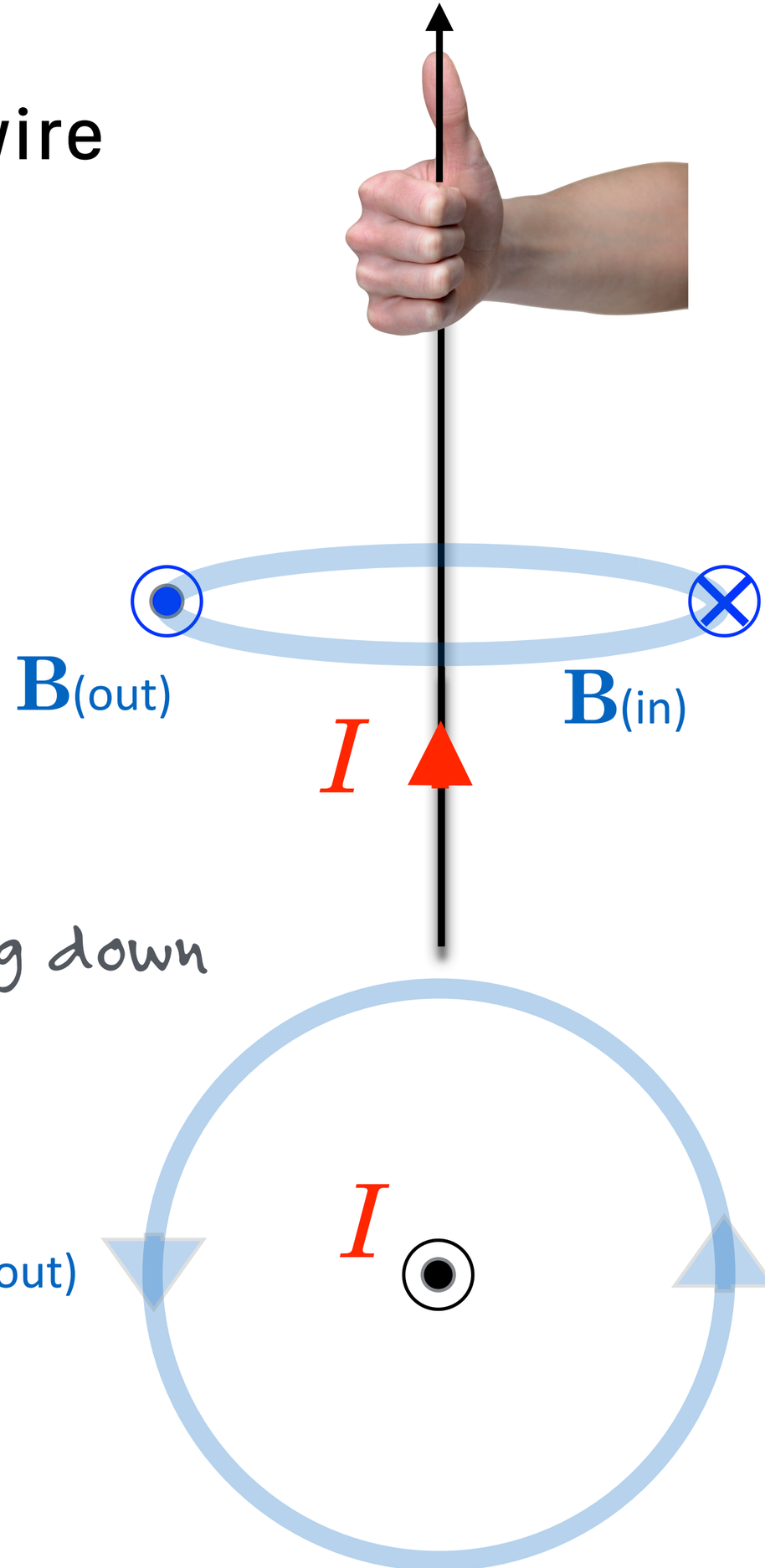


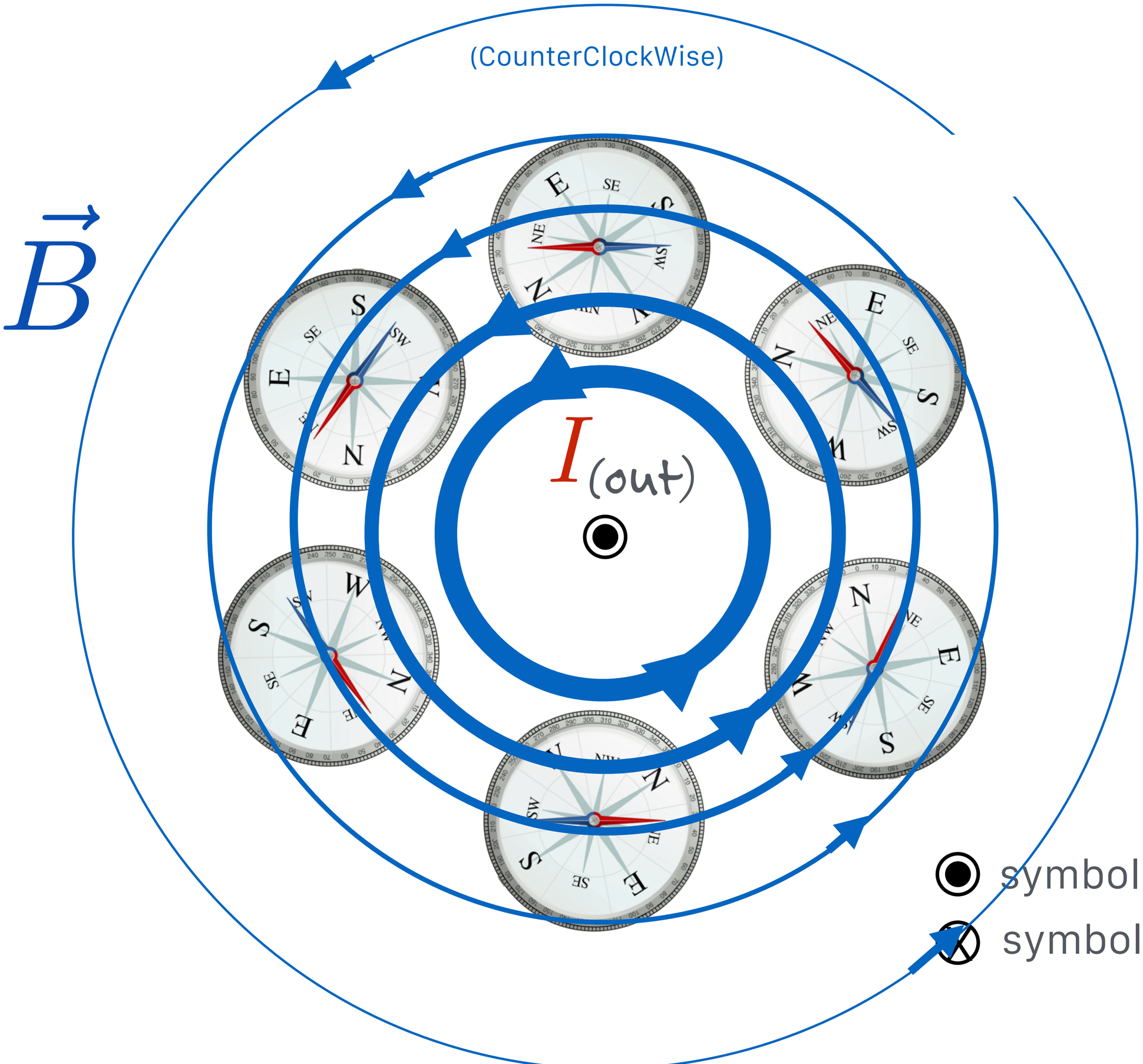

THE ARROW VIEW FOR VECTORS
FROM THE BACK
FROM THE FRONT

magnetic field of a wire

hands-on-learning

well, one hand anyway




(CounterClockWise)
$\vec{B}$
$I_{(out)}$
symbol for “out”
symbol for “in”

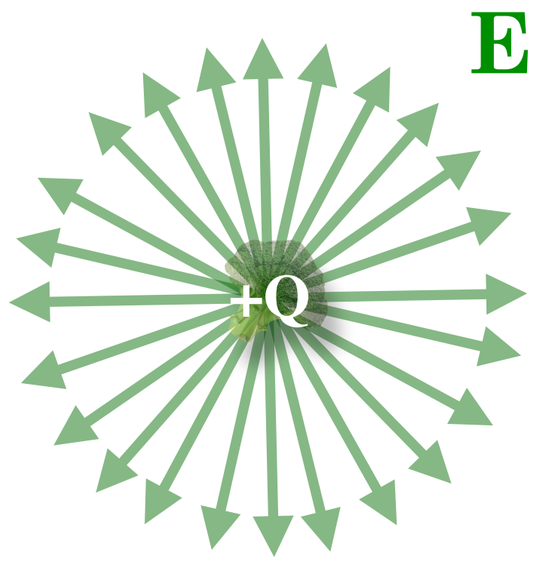
from Lesson 13

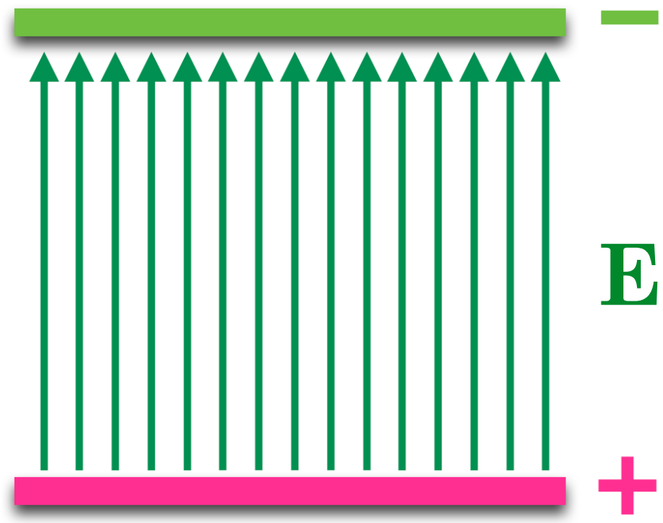
reminders

so: two kinds of fields

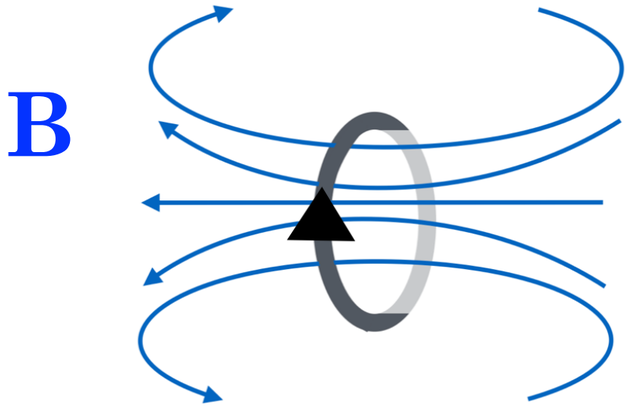
for two particular configurations of charges and currents

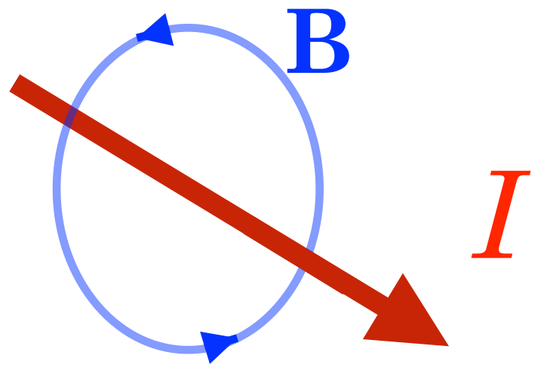
Electric Fields, $\mathbf{E}$ ⟵ **lines**: that stop and end on charges





Magnetic Fields, $\mathbf{B}$ ⟵ **loops**: that encircle currents





are they real?

"Perhaps you still want to ask, what is an electric field? Is it something real, or is it merely a name for a factor in an equation which has to be multiplied by something else to give the numerical value of the force we measure in an experiment?...First, since it works, it doesn't make any difference...."

Edward Purcell, *Electricity and Magnetism* (standard textbook for physics sophomores)

Faraday thought so.

Come on. Yes. Seriously. They're real.

James Clerk Maxwell

1831 — 1879

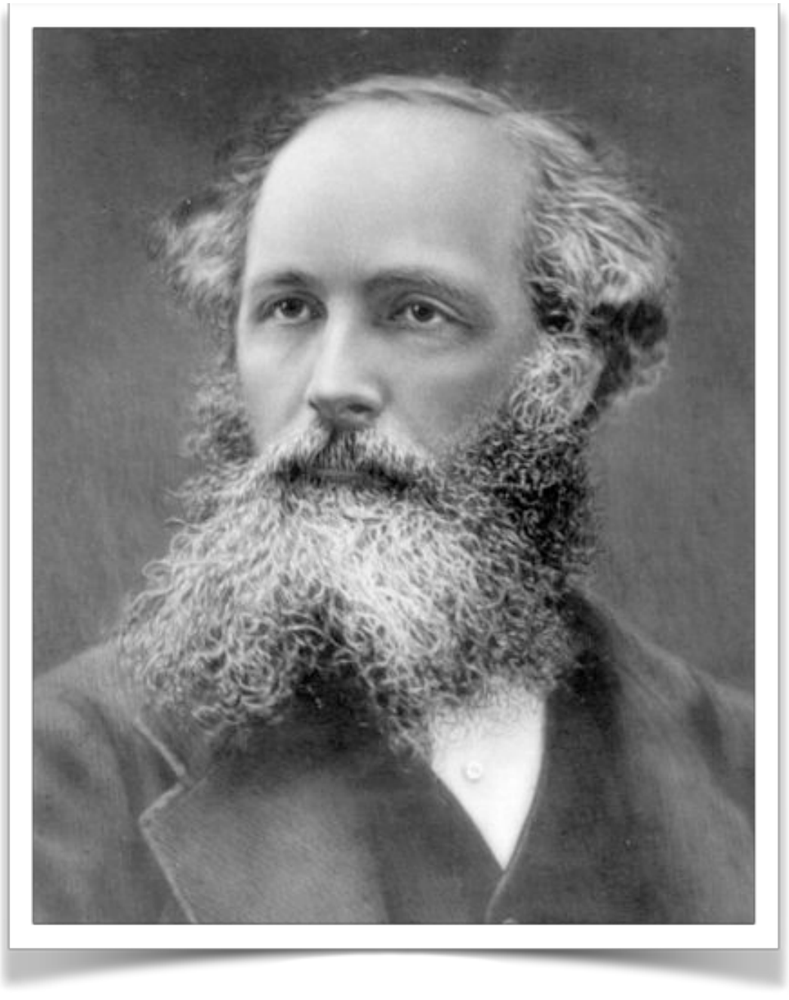
One of the most extraordinary theoretical minds:

Starters:

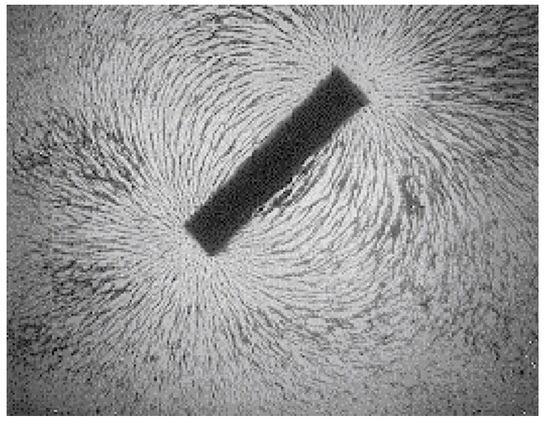
Newton, Maxwell, Einstein, Dirac, Feynman, Gell-Mann

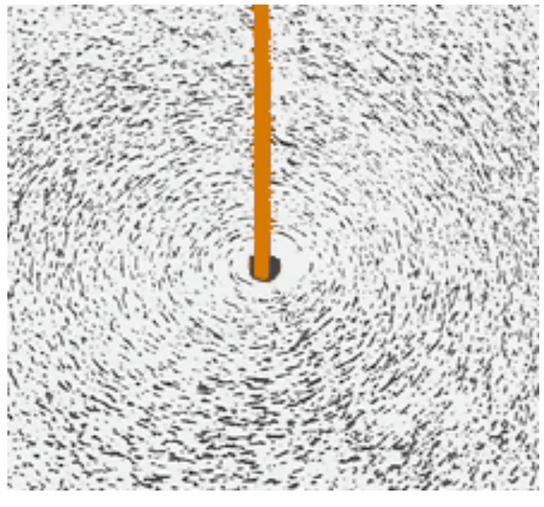
off the bench:

Bohr, Heisenberg, Fermi, and Gamow,



“Maxwell’s Equations” in pictures?





a changing B field creates an E field

a changing E field creates a B field

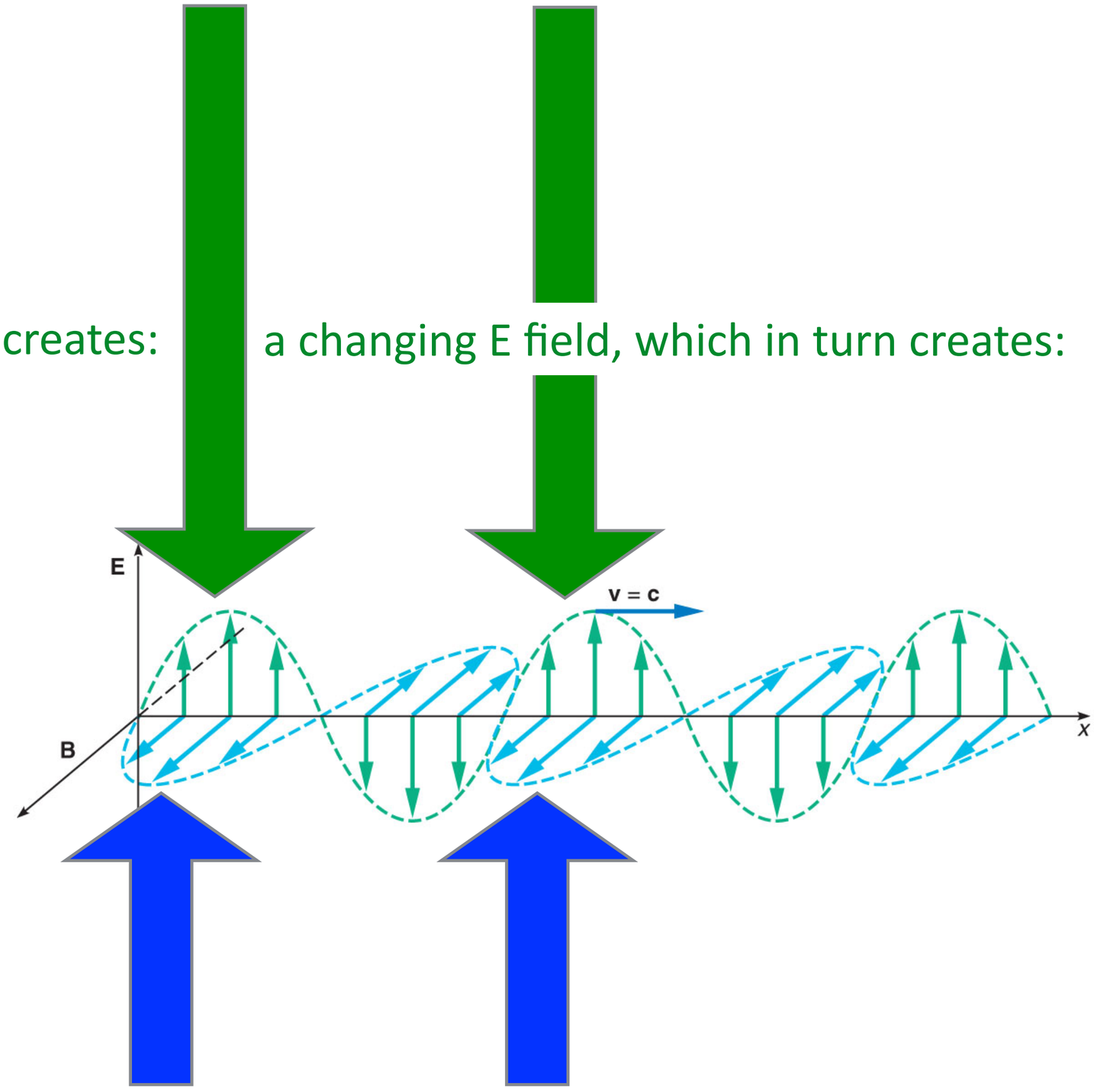
from his 4 equations

came coupled waves moving in time at the

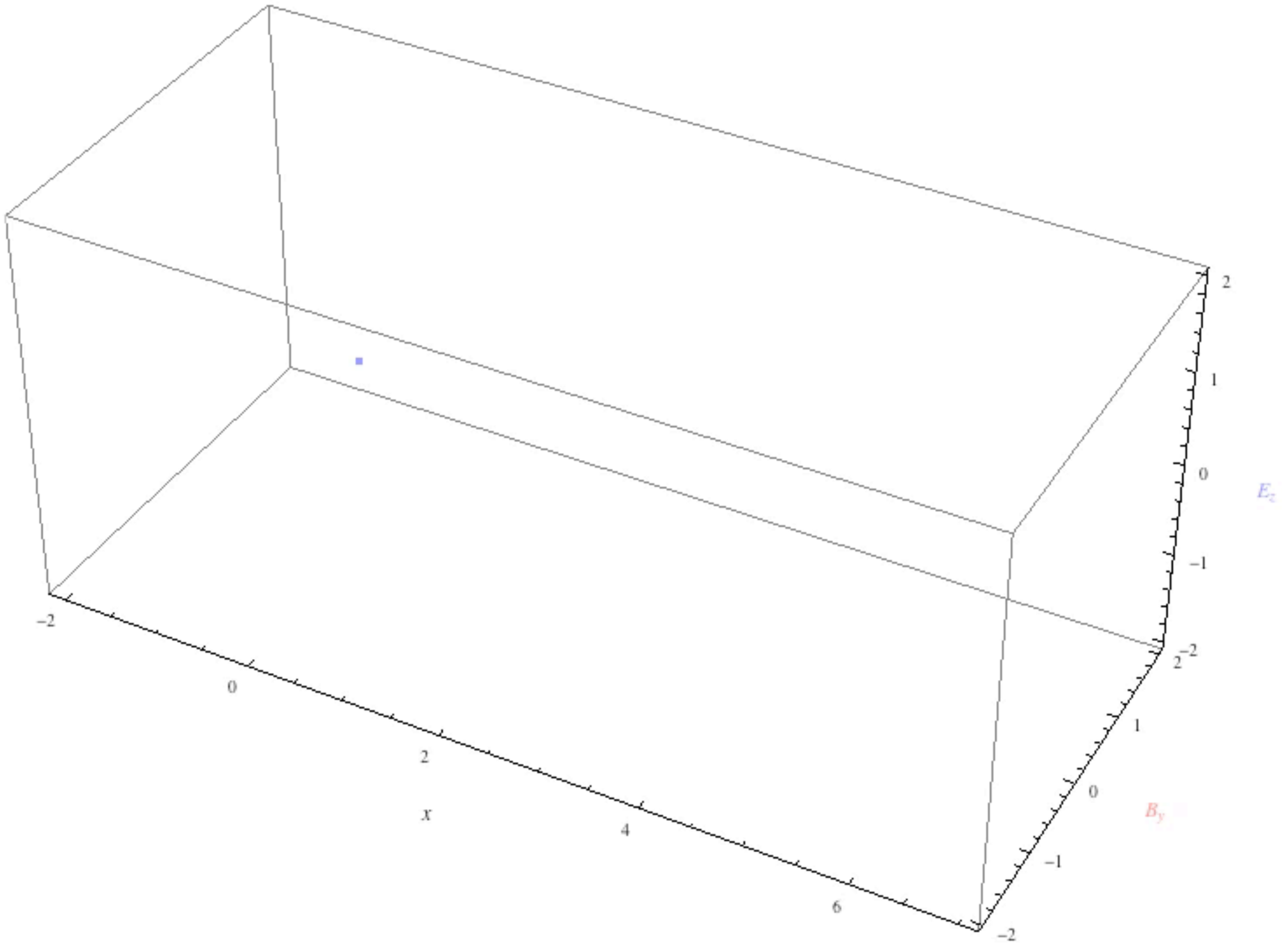
speed of light

a changing E field creates:

a changing E field, which in turn creates:



a changing B field, which in turn creates:


x
−2
0
2
4
6
2
1
0
−1
−2
−2
1
0
−1
−2

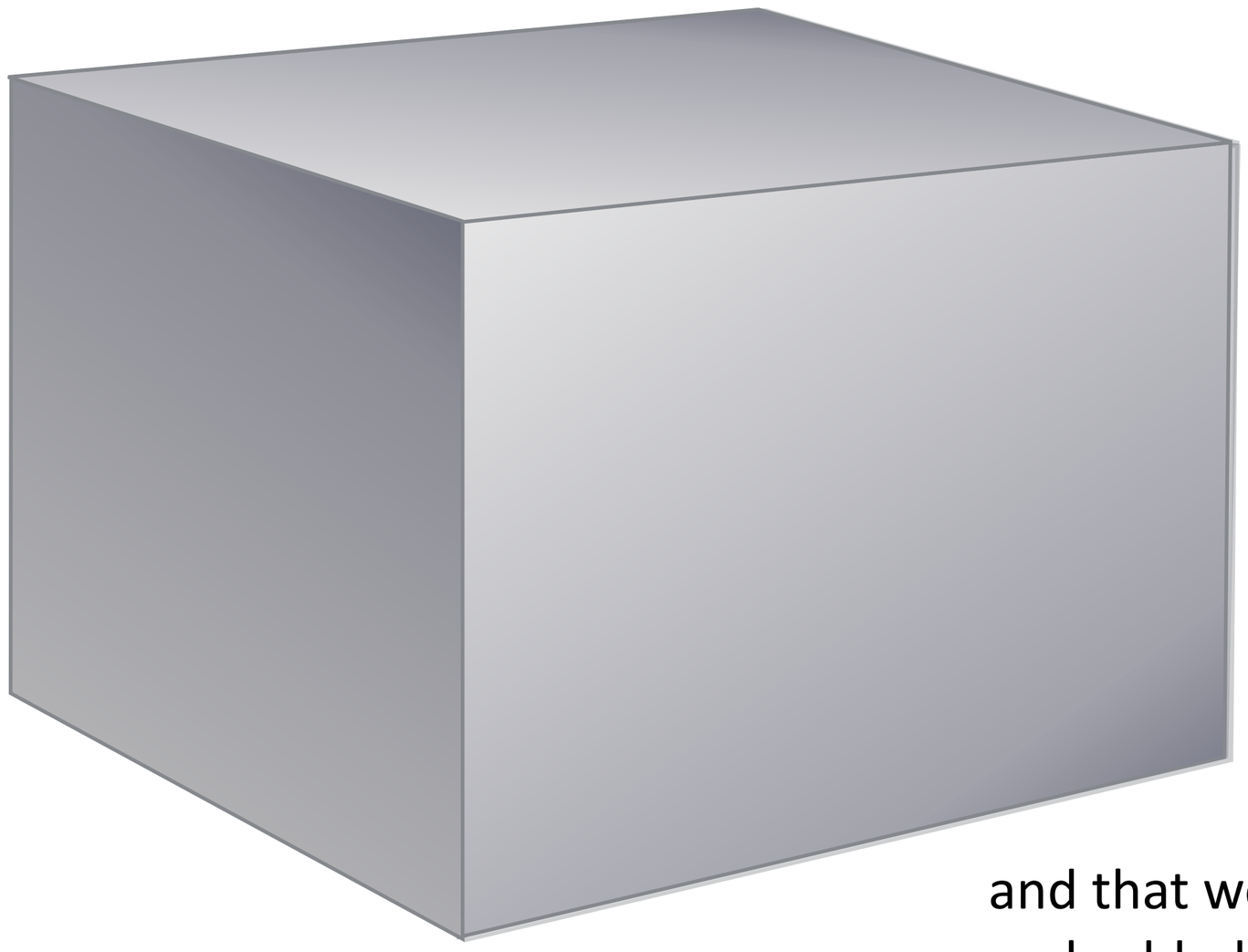
what’s waving?

“the Ether”

the 19th century Just-So story...

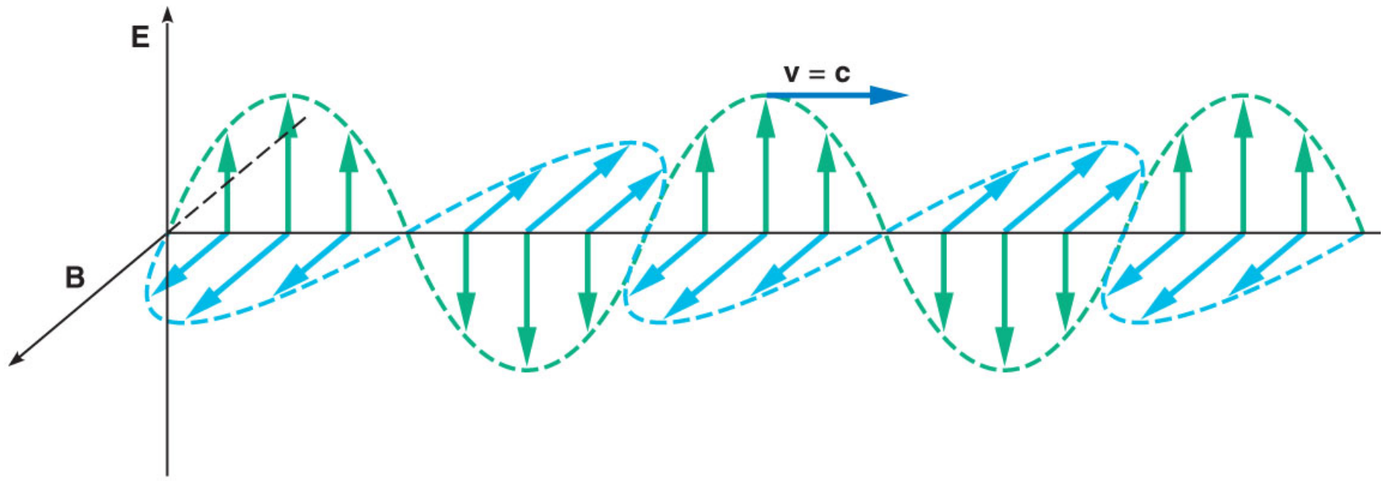
E and B vibrations are undulations in the Ether

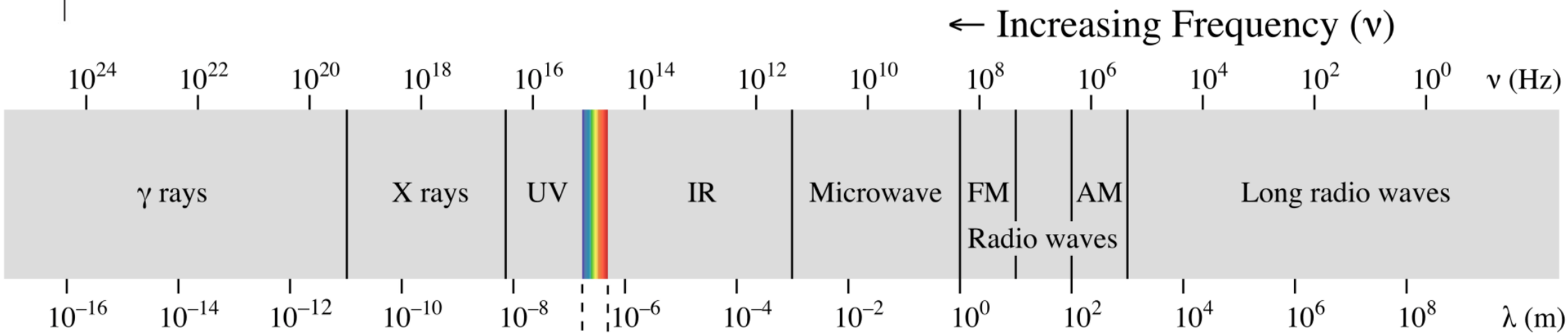
WRONG

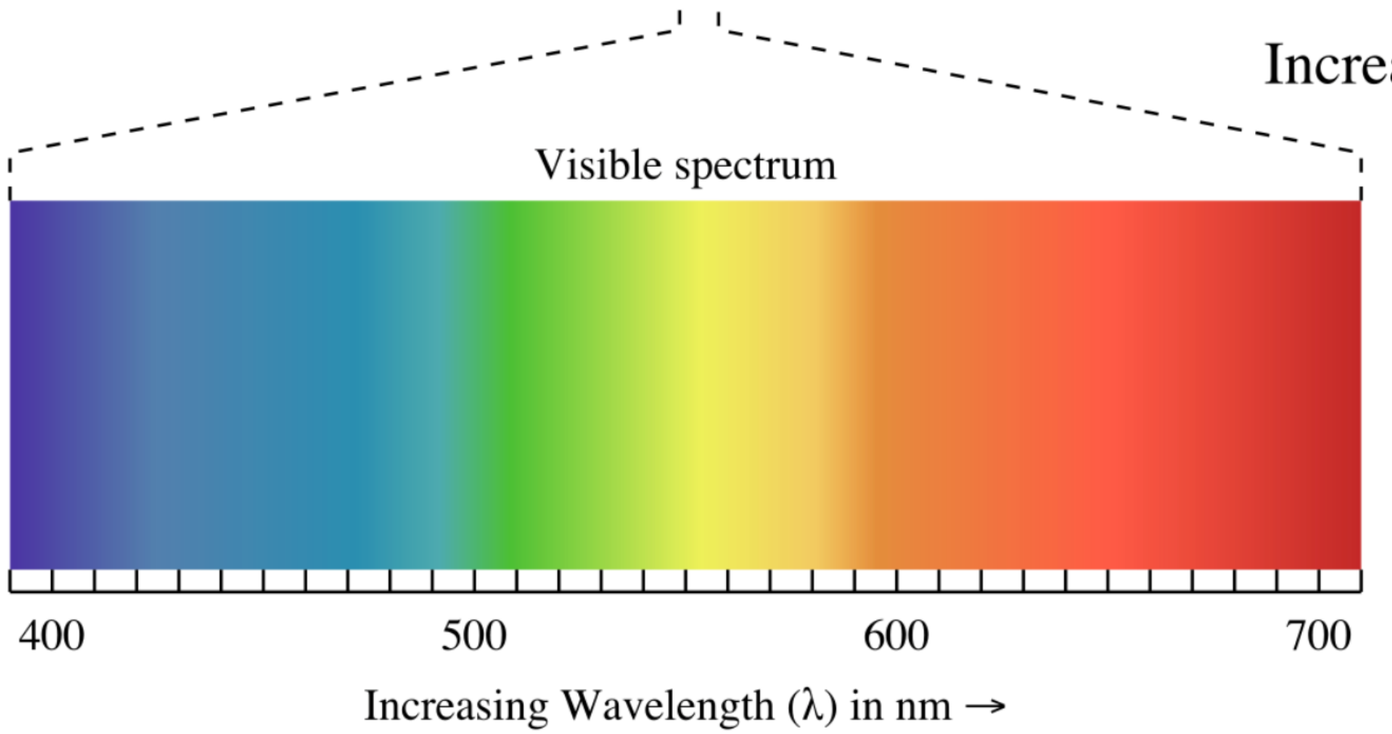


and that we’re embedded in the Ether, since we see the stars

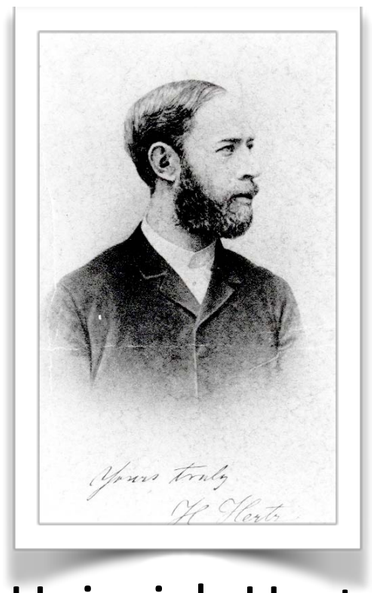
Modern Electromagnetic Spectrum







all travel at c = 3 x 10^8 m/s



Heinrich Hertz

1857 – 1 January 1894

relation alert: **speed of a wave**

refers to: $v = \lambda f$

example: middle C ~ 4 ft (=1.2 m) wavelength

f = 262 Hz, so speed of sound:

$v = 1.2 \times 262 = 314 \text{ m/s}$

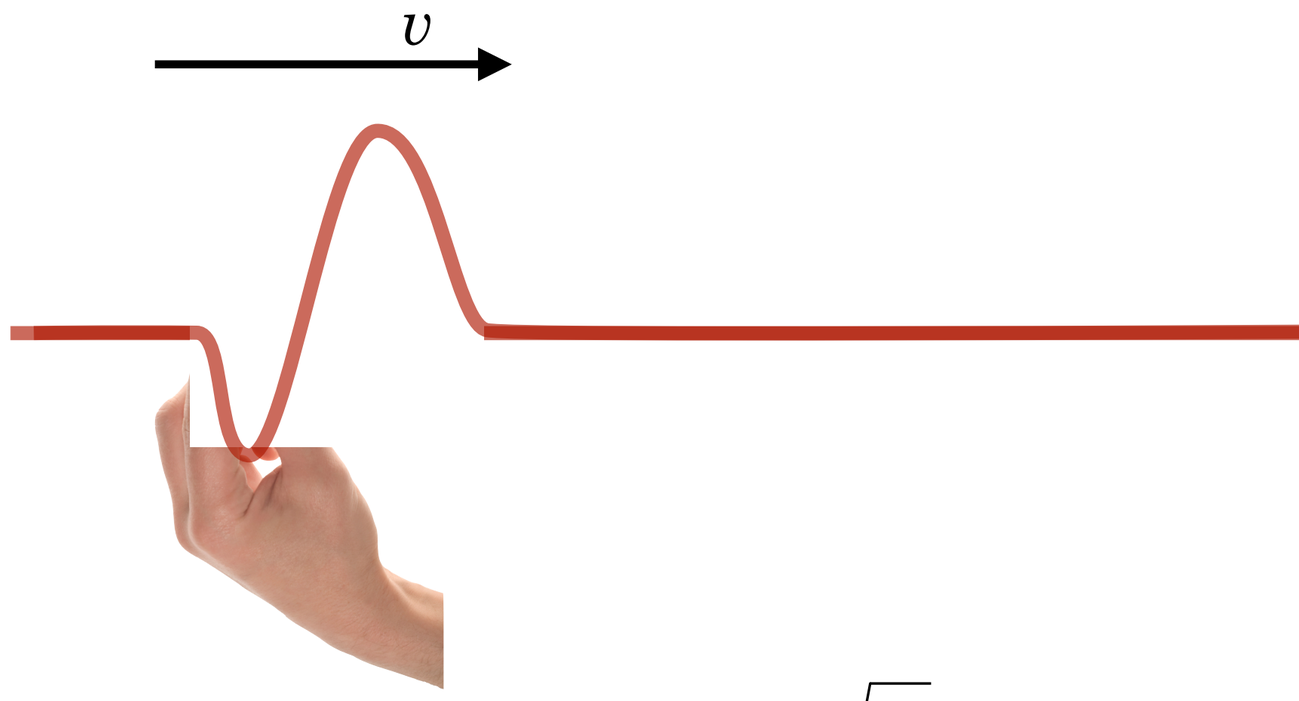
a wave is

a disturbance.

a way to transmit energy

without transmitting matter

one part is stretched, but the rope's tension restores it - and K is passed on to an adjacent part



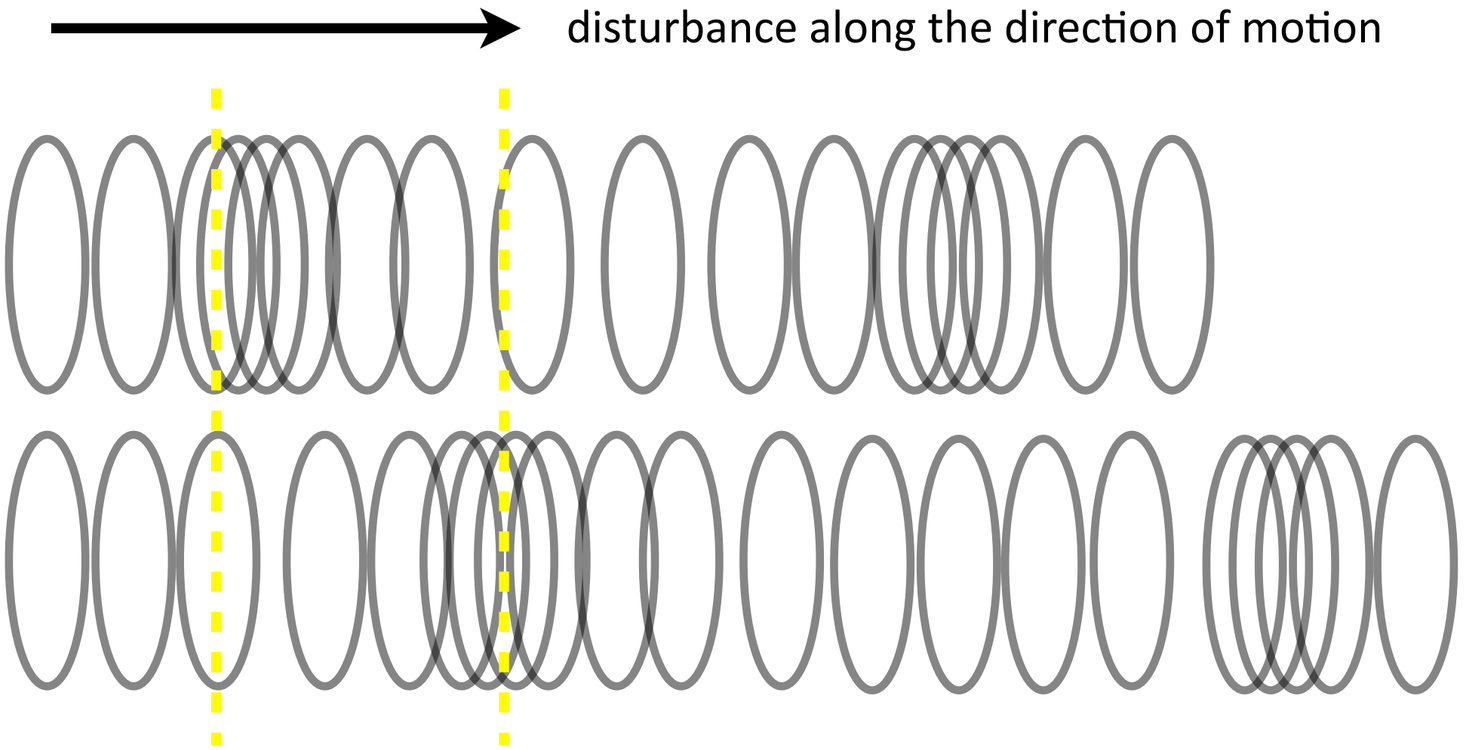
the *disturbance* moves with velocity $v = \sqrt{\frac{T}{\rho}}$

stiffer - faster

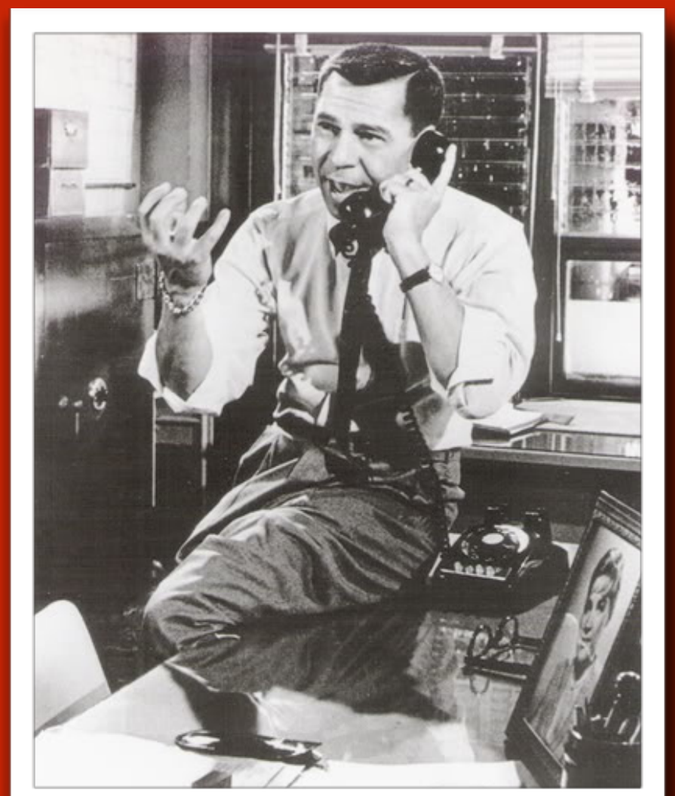
lighter - faster

2 kinds of waves

Longitudinal ***SOUND***

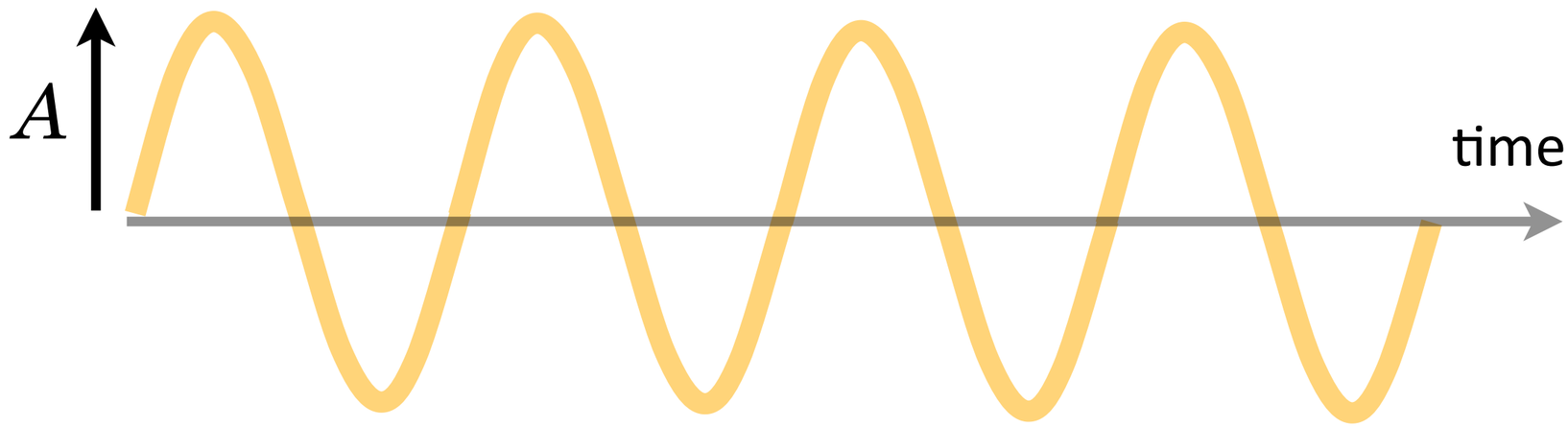


just some facts, Ma’am



maximum height of the disturbance: “Amplitude,” A.

“Intensity” is ~ A^2



wave speeds

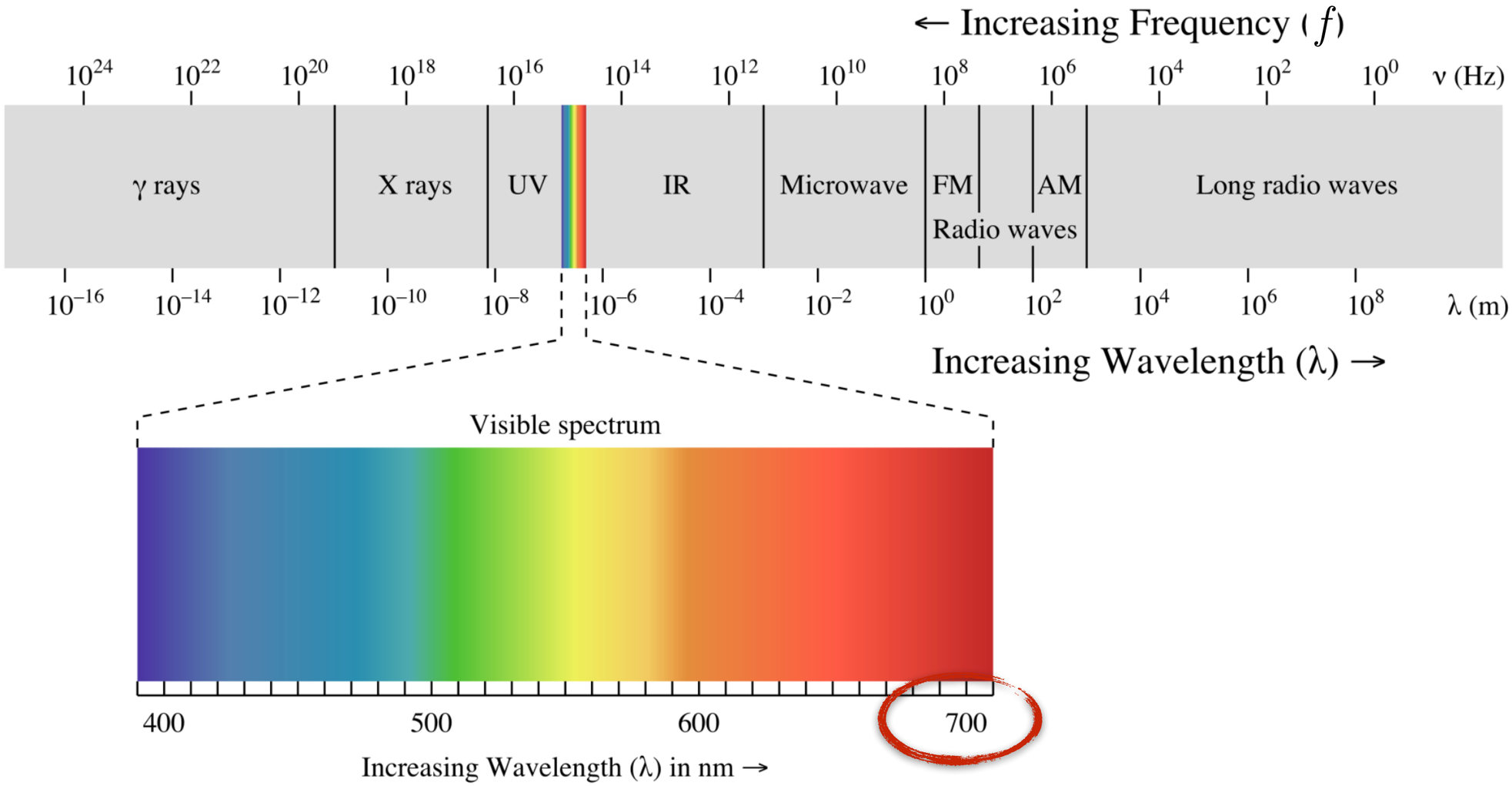
for sound in regular room temperature air?

about 300ish m/s: so about 30 ms to hear me in the back row

for light...anywhere?

$v = c = 3 \times 10^8$ m/s

$$v = \lambda f \rightarrow c = \lambda f$$



frequency and wavelength are coupled for light:

$$c = \lambda f$$

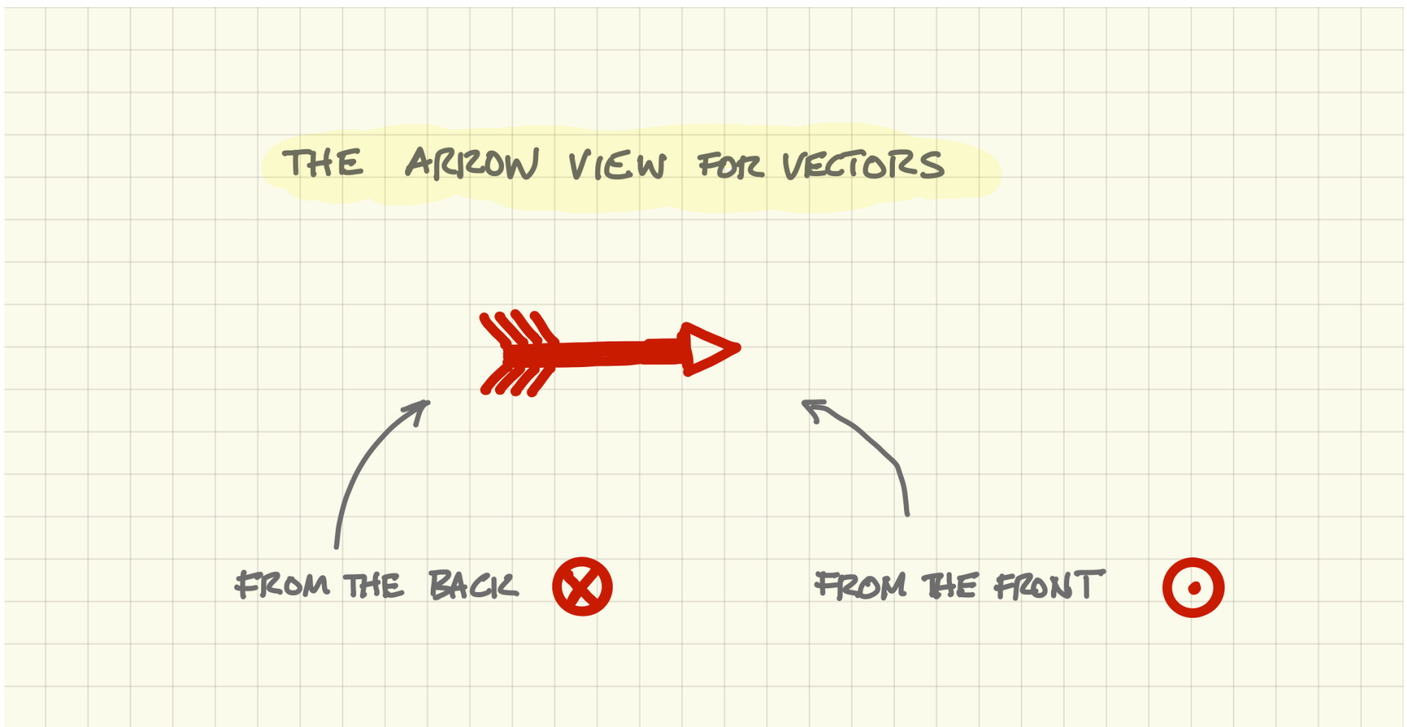
$$c = (700 \times 10^{-9}) f$$

$$\frac{c}{700 \times 10^{-9}} = f$$

$$f = \frac{3 \times 10^{8}}{7 \times 10^{-7}} = 0.42 \times 10^{15} = 4.2 \times 10^{14} \text{ Hz}$$

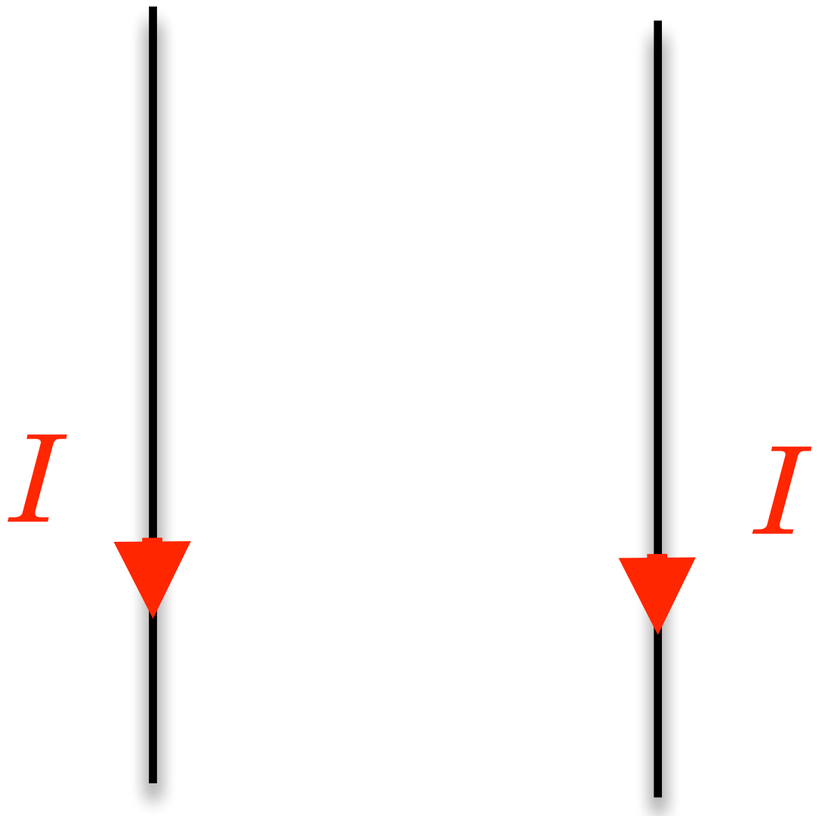
projects, continued

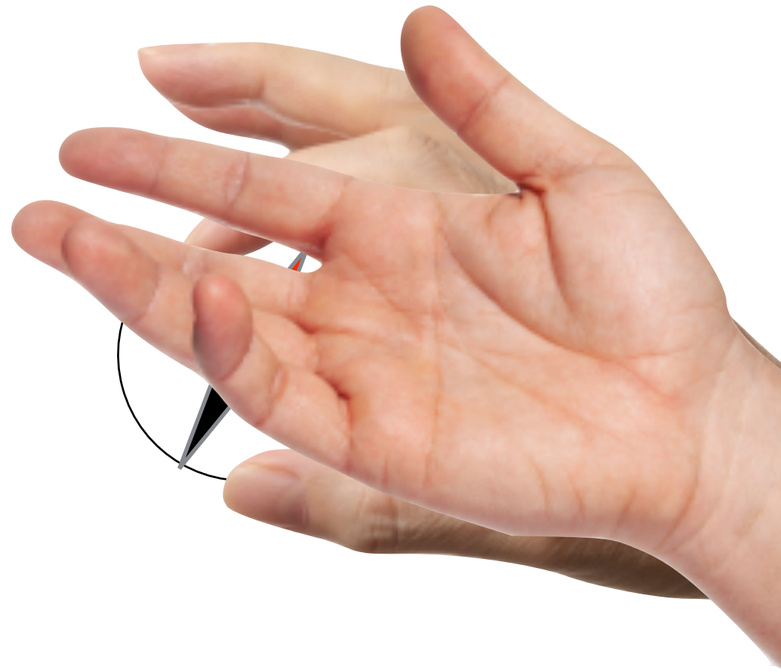
sing-along portion



Oersted’s compass?

could cancel out the effects





wait, wait, wait ...nothing!