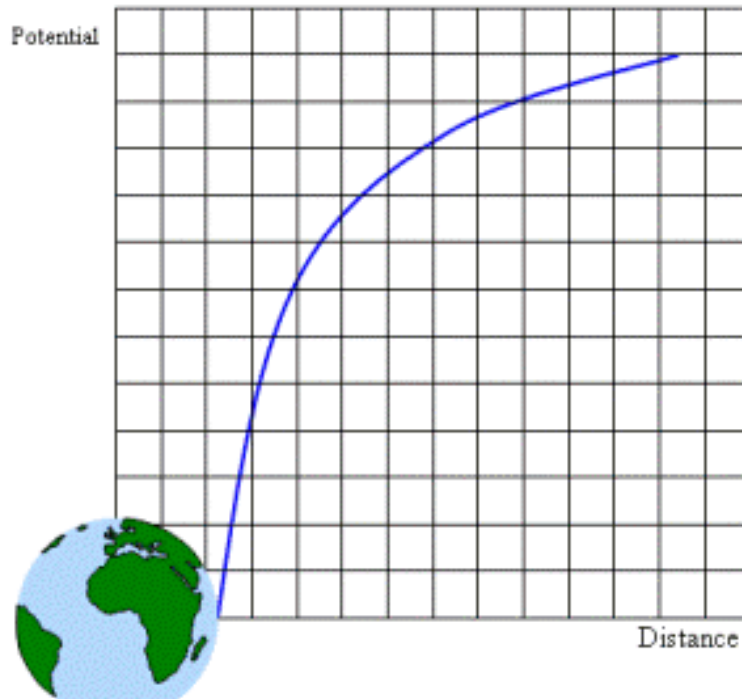


The “gravitational field”

is just the potential energy you would have at each altitude
(Which means: the amount of kinetic energy you’d have when you hit the ground, after falling from that altitude)



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1

Potential energy isn't *just* a cheat

It turns out the gravitational potential energy depends *only* on how high you go, so we have learned something new:

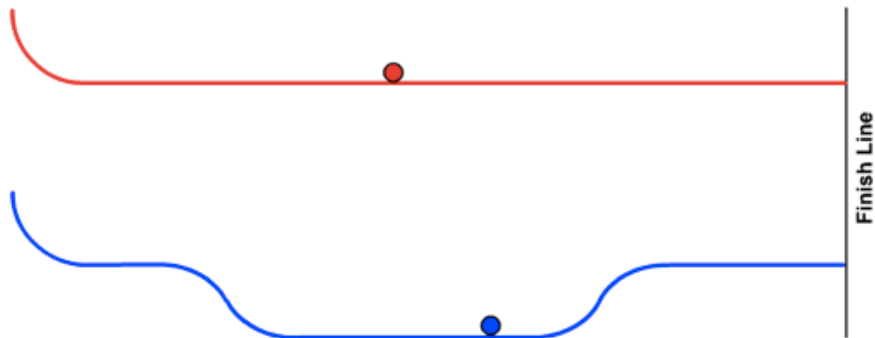
if you roll down and back up again, you get only to the same height.

QUIZ....

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2

Racing Balls



The acceleration due to gravity is down, approximately constant, and equal for both tracks.

You predicted the blue ball will win the race.



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Is energy always conserved?



New forms of energy

- Kinetic energy
- Potential energy
- Sound
- Heat
- ... others?

**Energy can be
transferred or transformed,
but not created or destroyed**

Levels of description

Questions...

- (0) **Was energy discovered, or invented?**
(is it a “real thing,” or just a way of keeping track?)
- (1) **How can we have an energy shortage if energy is conserved?**
- (2) **What is solar energy made of ?**

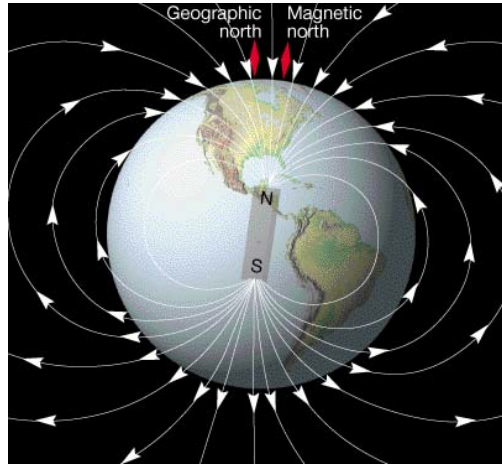
Electric charges attract or repel, sort of like the Earth & Sun

**Do they attract and repel each other “from a distance,”
or are there “electric fields” in space?**

**These fields would be like the gravitational field -- they tell
you how much energy a charged object (electron, proton, ...)
would have if it happened to be at a given position.**



Magnetic fields also describe forces things (magnets) *would feel*



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Ørsted: moving charges (“electric current”) create a magnetic field (1820)

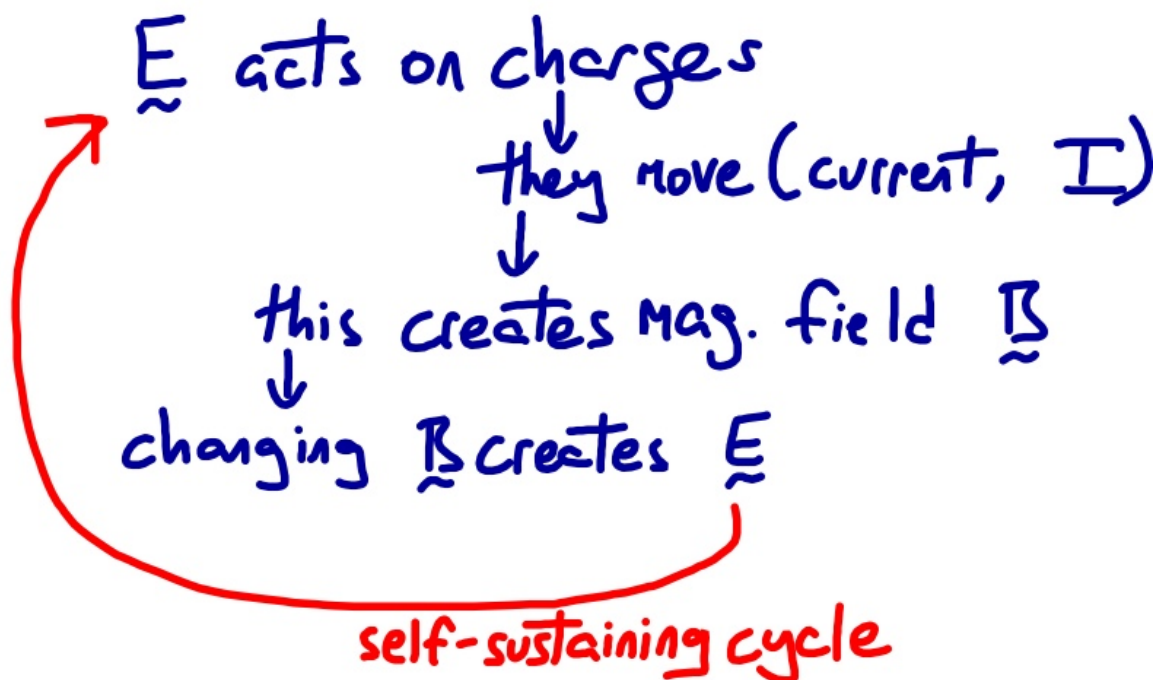
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Faraday: changing magnetic field generates an electric field (1830s)

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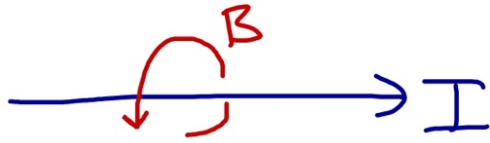
11



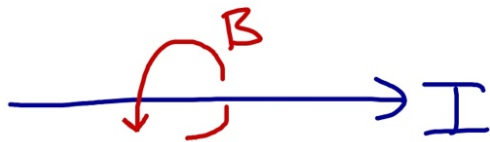
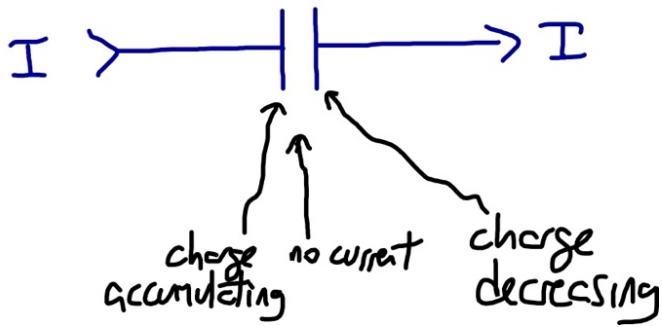
Is this something done by the *charges*, or if the fields themselves exist, can this happen even in vacuum???

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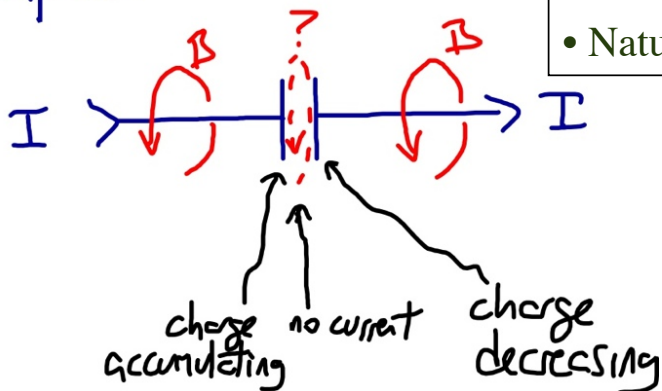
12



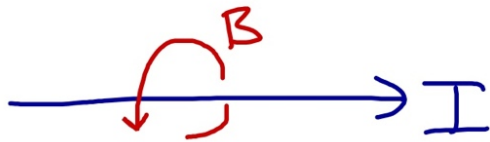
capacitor:



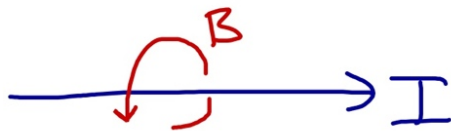
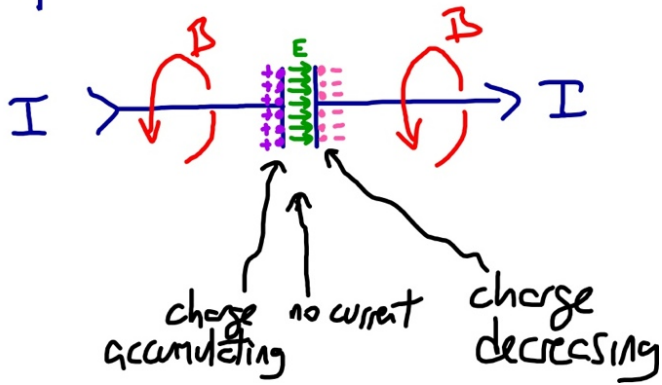
capacitor:



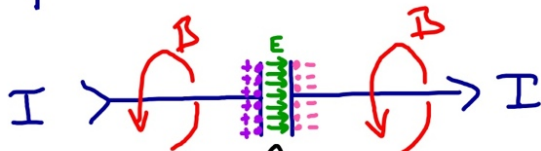
- Where exactly is “around the wire” and where “around the gap”?
- Nature hates a discontinuity...



capacitor:

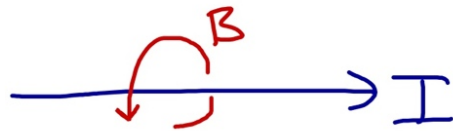


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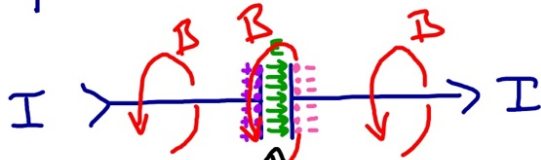


as more charge accumulates,
E gets bigger.

Maxwell: just as changing $B \rightarrow E$,
changing $E \rightarrow B$!



capacitor:



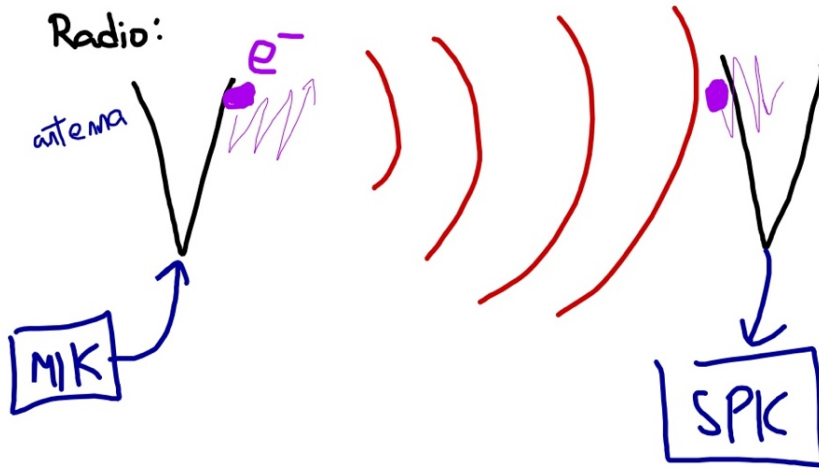
as more charge accumulates,
E gets bigger.

Maxwell: just as changing $B \rightarrow E$,
changing $E \rightarrow B$! (1861 and on)

Two asides

- “Elegance” may have been part of it, but I’m sneaking math under the rug – Maxwell actually saw that the equations Ørsted, Faraday, et alia had come up with were not *consistent* unless you added something else.
- It’s fortunate that math is so reliable, because the *picture* Maxwell had of these fields is something we consider completely crazy today – and yet we believe his results!
The picture may help you get the results, but it seems to be the math that guarantees that it’s right.
- “The unreasonable effectiveness of mathematics”

Maxwell *predicted* that E and B could exist on their own, and propagate through space



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One electron moves another

Fields, or action at a distance?

If I drop a stone in a pond and the ripple reaches you, don't you think that the water must exist?

Also: the transmitted uses up power — *whether or not* you ever receive the radio signal!

There is energy stored in the field itself.

(And energy is conserved “locally” – it can be transformed from one form to another, and it can move, but it moves at some finite velocity...)

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