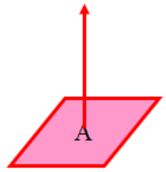
Noteguide for Lenz's Law - Video 21A **Name______________________________**

Magnetic Flux:

$\Phi = BA\cos\theta$

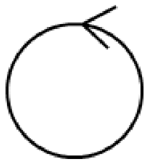
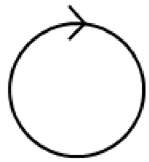
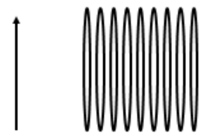
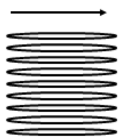
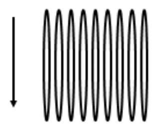
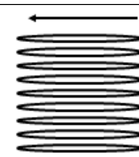
- Φ - Magnetic Flux in Webers
- B - Magnetic Field in T
- A - Area in m^2
- θ - Angle twixt B and A



For now, think of magnetic flux as the magnetic field multiplied by the area.

Lenz's Law states that if the flux in a loop of wire changes, it will induce a current whose flux <u>opposes</u> that change. Watch the videos so that you understand:

1. The direction of the flux caused by the current in a loop:

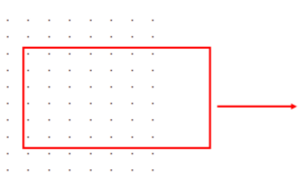
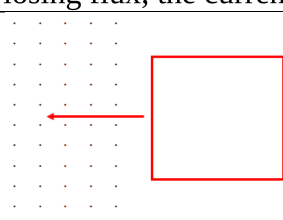
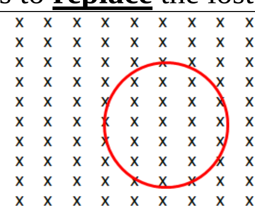
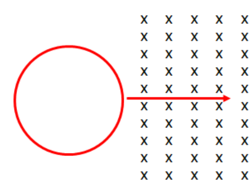
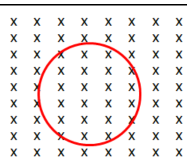
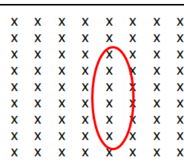
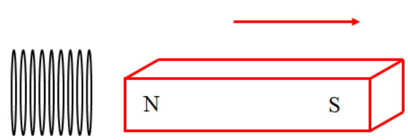
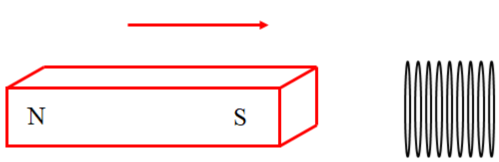
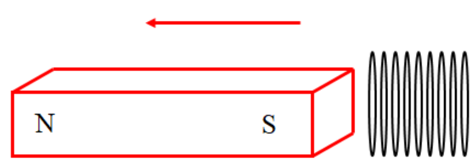
		 Current goes up in the front of the coil
 Current goes right in the front of the coil	 Current goes down in the front of the coil	 Current goes left in the front of the coil

2. The direction the current flows in the loop or solenoid due to a change in flux: (three steps)

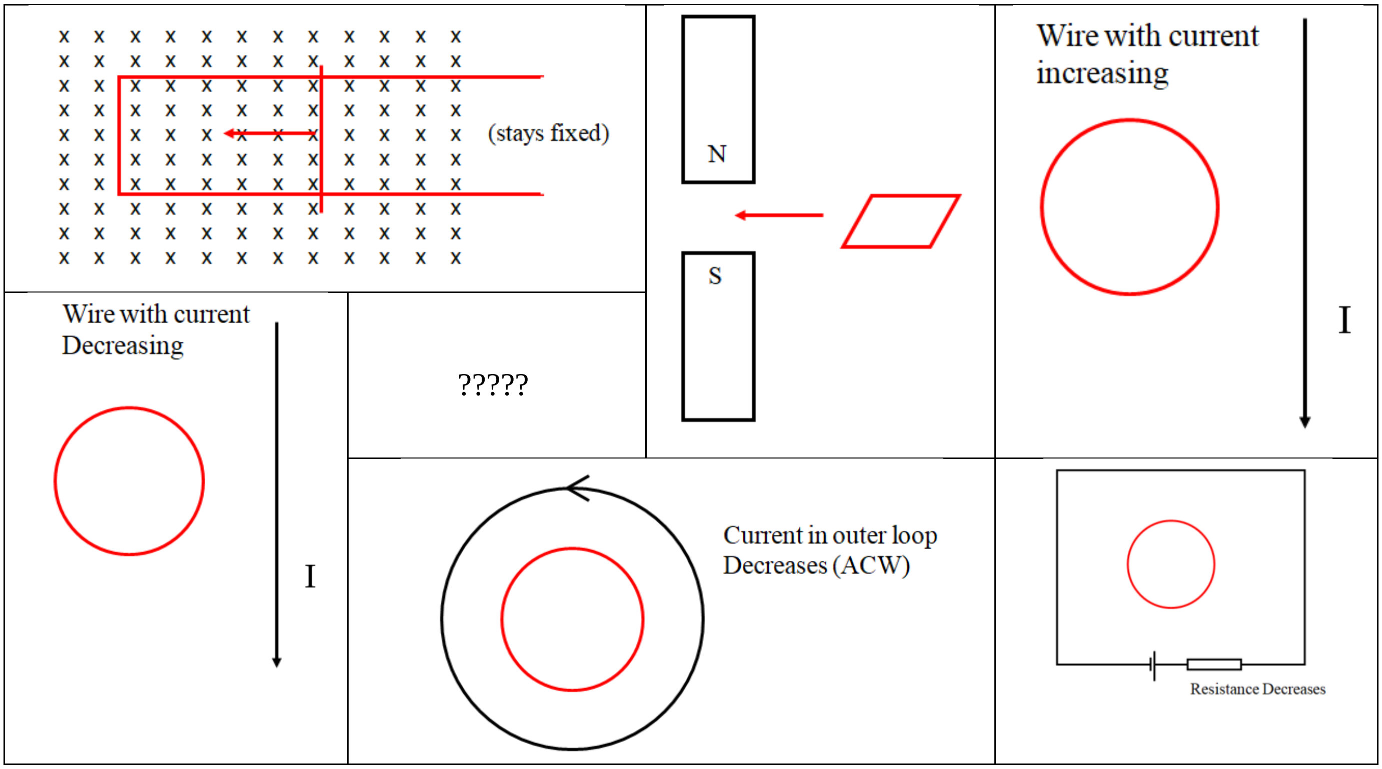
Find the direction of the change of flux. Are you gaining or losing flux, and which way is it?

a. If you are gaining flux, the current flows to **<u>oppose</u>** the change.

b. If you are losing flux, the current flows to **<u>replace</u>** the lost flux.

		 B increases into page	
 Before	 Loop has been rotated		
			

(more on the back)

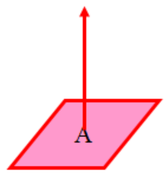

(stays fixed)
N
S
Wire with current increasing
I
Wire with current Decreasing
I
?????
Current in outer loop Decreases (ACW)
Resistance Decreases

Noteguide for Faraday's Law - Videos 21B **Name______________________________**

Magnetic Flux:

$\Phi = BA\cos\theta$

- Φ - Magnetic Flux in Webers
- B - Magnetic Field in T
- A - Area in m^2
- θ - Angle twixt B and A



Ways to change flux: (show)

$\Phi = BA\cos\theta$

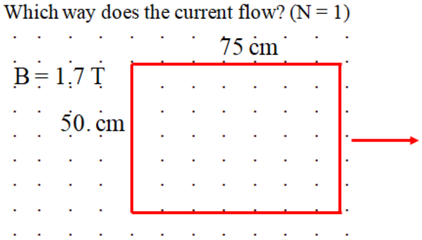
- Change B (magnetic field)
- Change A (area)
- Change θ (angle - rotate)
- Change any combination:
  - $\Delta\Phi = BA\cos\theta - BA\cos\theta$
  - (final) - (initial)

Faraday's Law: $\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$

(Maxwell's 3rd law)

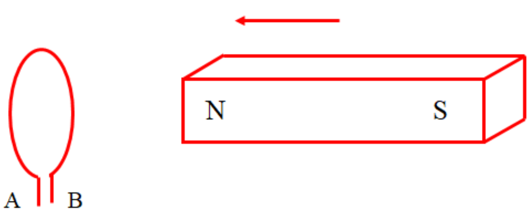
- ε - Electromotive force (voltage)
  (Current flows in a direction that opposes the change in flux)
- N - # windings
- $\Delta\Phi$ - Change in Magnetic Flux
- Δt - The time elapsed

Example: The loop is removed in 0.012 s. What is the EMF generated? Which way does the current flow? (N = 1)



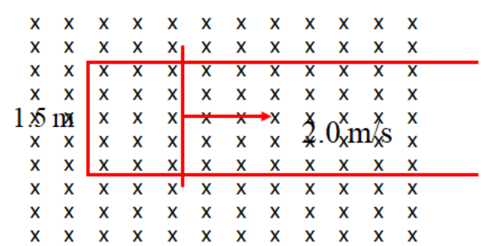
Whiteboards:

The approach of the magnet makes the B field inside the 3.0 cm **diameter** loop go from 0.025 T to 0.175 T in 0.0035 s. What is the EMF, direction of the current, and which electrode is + (current flows out of it)



(0.030 V, ACW, A is +)

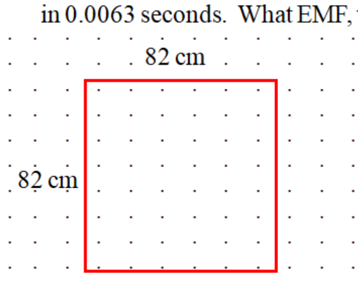
The bar moves to the right at 2.0 m/s, and the loop is 1.5 m wide. What EMF is generated, and which direction is the current?



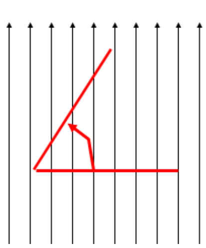
B = 3.2 T

(9.6 V, ACW)

The loop is rotated about an axis that lies in this page from its current position to an angle of 57° with the page in 0.0063 seconds. What EMF, what direction current?



side view



B = 5.3 T

(260 V, ACW)

Noteguide for Moving Conductors - Videos 21C **Name**______________________________

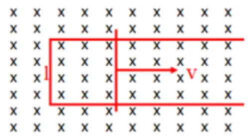
$\mathcal{E} = -N \frac{\Delta\Phi}{\Delta t}$

$\Phi = BA\cos\theta$

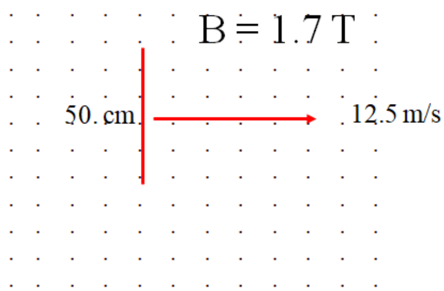
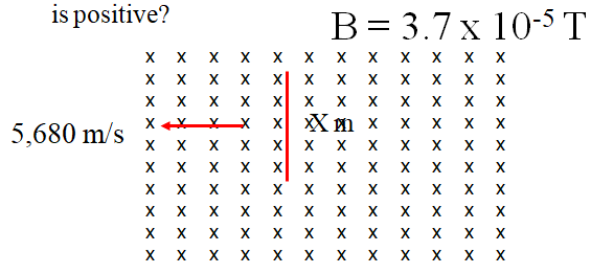
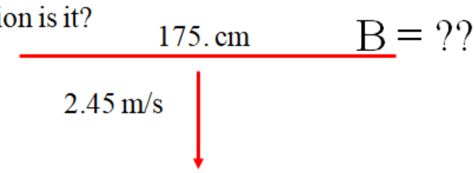
Derive

$\mathcal{E} = Bvl$

- B = mag field in T
- v = velocity of conductor in m/s
- l = length of conductor in m
- show direction with x product



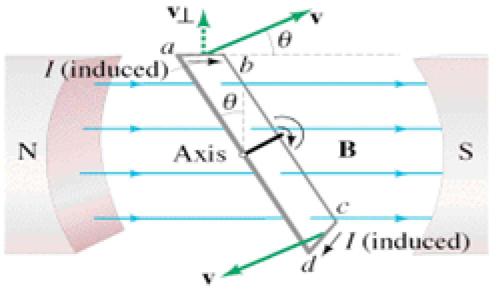
Whiteboards:

The wire moves to the right at 12.5 m/s. What is the EMF generated? Which end of the wire is the + end?  (11 V, bottom is +)	How long does the wire need to be to generate a potential of 45 V from one end to the other? What end is positive?  (210 m, bottom is +)
The wire has a potential of .215 V, and the right end is positive. What is the magnetic field, and which direction is it?  (0.0501 T ,into page)	this space for rent

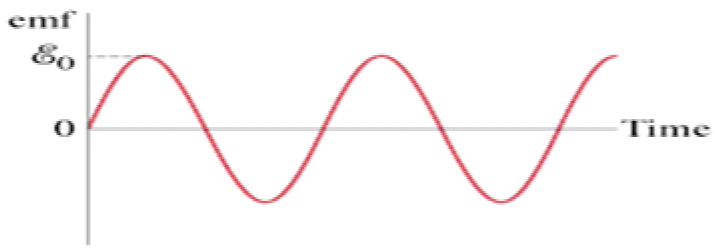
If the moving conductor is not just a wire, but a sheet of conducting material, this gets more interesting. Currents are induced by changing flux. We can talk about this in class next time. I have demos.

Noteguide for Alternators - Video 21D **Name**______________________________

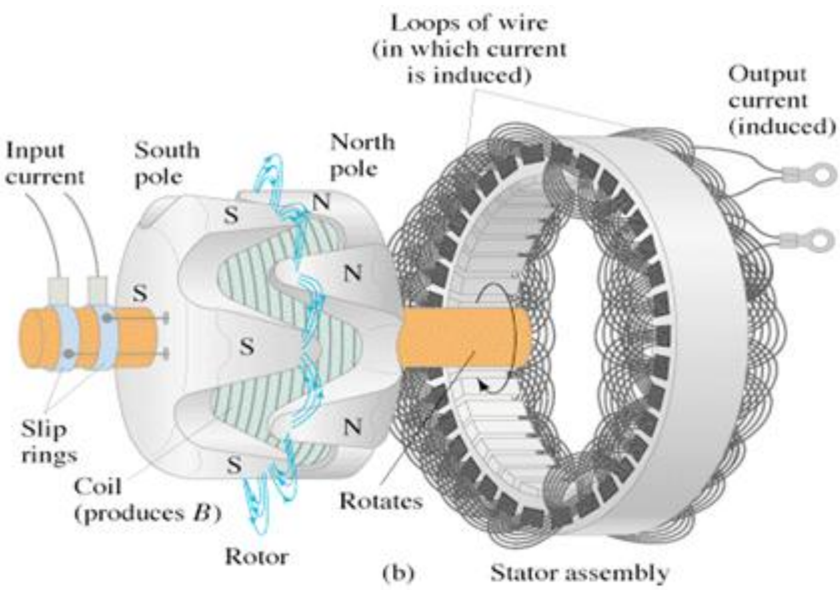
Loop Rotating in B field (show)



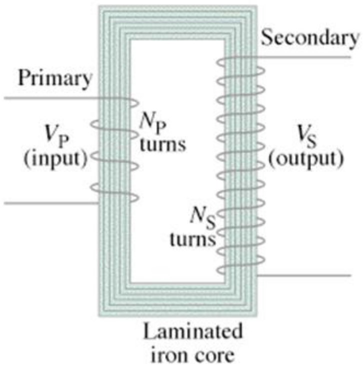
$$\mathcal{E} = -N\frac{d\,BA\cos(\omega t)}{dt}$$



Solution for $\mathcal{E}$:



Noteguide for Transformers - Videos 21E **Name**____________________________



$$\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s}$$

Example: A transformer has 120 primary windings, and 1450 secondary. If there is an AC voltage of 15 V, and a current of 350 mA on the primary, what is the current and voltage on the secondary?

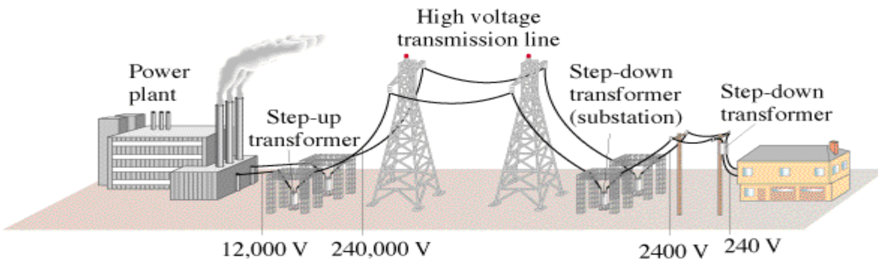
Whiteboards:

1. A transformer has 120 primary windings, and 2400 secondary windings. If there is an AC voltage of 90. V , and a current of 125 mA in the primary, what is the voltage across and current through the secondary? (1800 V, 6.25 mA)

2. A transformer is operating at 12.5 W. It steps 110 VAC down to 9.6 VAC. There are 320 primary windings.
A) How many secondary windings are there?
B) What is the current in the primary and secondary?
(28 windings, 0.11 A, 1.3 A)

3. An AC Arc welder can deliver 550 Amps of current. If it draws 18 amps from the wall at 120 VAC, what is the delivered voltage? If the primary has 1200 windings, how many does the secondary have? (3.9 V, 39)

Noteguide for Power Transmission - Videos 21F **Name**___________________________



Example:
If you transmit 1000. W at 120 V on wires that have a resistance of 2.0 ohms, what power is lost?

If you transmit 1000. W at 12,000 0V on wires that have a resistance of 2.0 ohms, what power is lost?

Whiteboards:

1. If you transmit 1300. W of power at 600. VAC, how much power is lost if the lines have a resistance of 1.70 Ω? (7.98 W)	2. If you wanted to transmit 7800. W of power over 5.20 Ω power lines, what voltage would you need to use to waste only 6.30 W? (7086 V)
3. You transmit 23,000. W of power at 19,300 VAC and waste only 8.20 W. What is the resistance of your transmission lines? (5.77 Ω)	4. You are wasting 9.50 W of power, when you transmit at 32,400 VAC on 2.30 Ω transmission lines. What is your transmitted power? (65,848 W)

Noteguide for Maxwell's Equations - Video 21G **Name______________________________**

Differential equations	Meaning
$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$	The electric flux leaving a volume is proportional to the charge inside.
$\nabla \cdot \mathbf{B} = 0$	There are no magnetic monopoles; the total magnetic flux through a closed surface is zero.
$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$	The voltage induced in a closed circuit is proportional to the rate of change of the magnetic flux it encloses.
$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$	The magnetic field induced around a closed loop is proportional to the electric current plus displacement current (rate of change of electric field) it encloses.

Specific Heat of Water

We are going to use an electric pot to calculate the specific heat of water. We will calculate the electrical power it is consuming, time how long it is on to get the energy delivered, measure the mass of the water, and its temperature rise and voila!

Here's what to do:

1. Carefully measure 1.5 liters of water into the pot. **Write down the mass and the uncertainty of the mass.** The uncertainty of the mass will be twice half the smallest division on the graduated cylinder. Don't turn it on yet, but place it on the base, and put the thermometer in and let it come to equilibrium. **Measure the initial temperature, and estimate the uncertainty of the temperature.**
2. Put the multimeter on 200 VAC, and CAREFULLY plug the leads into the same strip as the pot. Don't read the voltage yet, wait until the pot is on.
3. Get the stopwatch ready, and turn on the pot for 4 minutes, (**Write down the time you use and its uncertainty**) and then turn it off. While it is on write down the voltage. **The voltage will vary, so come up with what you think is an average, and an uncertainty.**
4. Watch the thermometer, and read the highest value it reaches. **Write the temperature down and its uncertainty**.
5. Take out the thermometer, pour out the water, take the pot off its base, turn it over, and with the multimeter on 200 ohms, **measure the resistance of the leads and its uncertainty**, (Touch the leads together firmly), and the **resistance of the heating element and its uncertainty.** (Turn switch to "on", and find the resistance between the outer two plugs on the bottom. Don't forget to turn the switch off when you are done.)
6. Make a nice **data table with units and uncertainties.**

How to calculate:

1. Find the change in temperature and the uncertainty of the change by subtracting initial from final temperature. Remember, the uncertainty of a difference is the sum of the uncertainties.
2. Find the resistance of the heating element and its uncertainty by subtracting the resistance of the leads from the resistance you measured between the two prongs on the pot.
3. Calculate the power delivered to the element from the voltage and the resistance.
4. Calculate the energy delivered to the water by multiplying time by power.
5. Use $Q = mc\Delta T$ to find C
6. Use $\frac{\Delta C}{C} = 2\frac{\Delta V}{V} + \frac{\Delta R}{R} + \frac{\Delta m}{m} + \frac{\Delta T}{T} + \frac{\Delta t}{t}$ to find the uncertainty of the specific heat.
7. Express the specific heat as a best guess +/- an uncertainty.

How to conclude:

1. Citing data from your experiment, and what the accepted value is for the specific heat of water, (Look it up. it actually depends on the temperature....) **make a logical argument as to whether the accepted value does or does not fall within your uncertainty.**
2. Heat almost certainly was lost to the surroundings. Would that make your value for C too high or too low. **Explain why**
3. List at least three main sources of error in the experiment. (I can think of about ten...)
4. For your three sources, explain how we might mitigate them.

Magnaprobe Lab

0. Pick up a magnaprobe from the paper from one of the outlines. These are actually very expensive little things, so be very gentle with them. Try to avoid sticking them to anything. The red end is the north pole end, and so it is like the tip of an arrow; whichever way the red end points, so points the magnetic field.

A. The Fixed Magnets.

1. Move the probe around the rectangular fixed magnet and let the magnaprobe trace out the magnetic field. Which end of this magnet is the North pole end?
2. The rock looking thing is a piece of lodestone – magnetic ore from the earth. Map out its magnetic field. Where is its north pole?
3. Carefully figure out on the hard drive magnets taped to the counter where the N and S poles are. Inside the hard drive they would face each other.
4. Check out the see-through computer hard drive.

B. The mysterious Levitation Spinny Magnet.

Solve the mystery that is the levitation spinny magnet using your magnaprobe. Where are magnets hidden in the base, and spinny part? What is their polarity?

C. Electric motors

Check out the electric motors. Where are the poles on the fixed magnets? Look at the motor for the hard drive. Find the poles on the rotor (The thing that spins attached to the platters)

D. The hand crank generator.

Turn this generator gently – it is very expensive to replace. Try turning the generator with nothing attached, and then connect it to the bulb. Notice how the resistance changes. Now try connecting the clips together in a dead short. Notice how it is really hard. The idea here is that the work you are doing turning the crank turns into electrical power. The more current that flows, the more work you must do. Try the hand crank flashlight. Squeezing the handle makes a generator spin inside the body of the flashlight. How does the light stay lit when you are not actually squeezing the handle?

E. A current carrying straight wire.

Turn the power supply on, and check to see that about 4 A of current is flowing. Find the large square made of many windings. Pick the vertical side nearest you and treat it as a long straight wire. Use the wire right hand rule to predict which way the magnetic field wraps around the wire. (Thumb – I, fingers wrap as B) Now use the magnaprobe to confirm this.

F. Flat solenoid.

Now treat the large square with many windings as a flat magnet. Use the right hand rule for solenoids to determine where the north pole is on this magnet. (fingers wrap as I, thumb is the N pole) Use the magnaprobe to check this. Figure out which way the field is in the area inside the coil in general.

G. The long long solenoid.

Turn the power supply on and check to see that a current of about 4 A is flowing. The current is coming out of the red terminal of the power supply, and going into the black terminal. Use your right hand rule for solenoids to determine the north pole for this solenoid. (fingers wrap as I, thumb is the N pole) Generally check out the direction of the magnetic field around and inside the solenoid.

Put your magnaprobe back on the paper where you found it.

H. BusyTown

By reaching under the box, find the little magnets stuck the underside of the street. Use this to drive your little car around the streets of BusyTown. Remember to stop at the intersections – they are all four way stops, and also stay on the right side of the road – because this isn't Britain, is it?? See if you can find your way to the gas station, the antique shop, and the shoe store. But seriously, you can steer the car, so how must the poles of the magnets be laid out above and below the cardboard?