Circle your lab day and time.

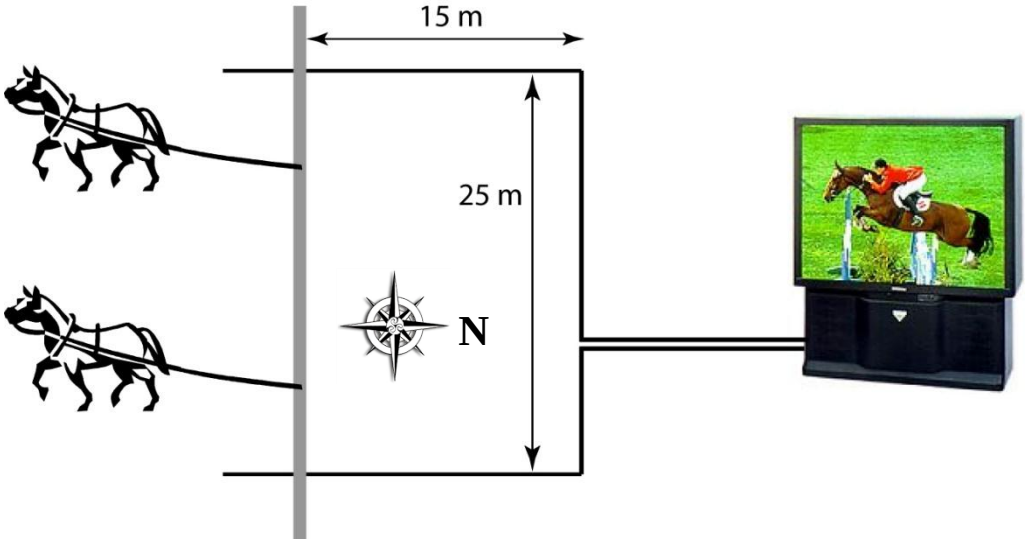
		Tue	Tue	Tue	Wed	Thu	Thu	Fri
Your name:								
TA name:		10-12	12-2	2-4	12-2	10-12	12-2	2-2

Written HW 5: A Home-built Generator
(due Friday, Nov. 2nd, 2012 at 2 PM)

Turn in this written homework in the appropriate slot in the brown Homework Cabinet at the entrance of the HelpRoom, Duane G2B90. Please STAPLE pages together, and **put your name and TA name at the top of every page!**

In all written homework, you will be graded on the clarity and completeness of your answer. ***No credit*** *will be given for an answer in a calculation without a derivation, even if the answer is correct. A calculation without units is also incorrect.*

A Boulder farmer, frustrated by her monthly electricity bill, decides to power her extra-large-screen television set by using a home-built generator. She knows that the Earth acts like a huge magnet and wants to make use of this magnetic field to generate an electromotive force (voltage difference) for this TV. The generator is made up of two large conductors coming out of the house, connected to a large sliding (conducting) rail pulled by her two horses, as shown below. In Boulder the angle of the Earth's magnetic field, which is pointing into the ground, with the horizontal (ground) is 66^{o} and the magnitude of the field is 53 μT (micro T). The TV acts effectively like a 9.8 Ω resistor in the circuit, and the friction between the moving parts is negligible.



(a) Redraw the set-up and show the direction of the Earth's magnetic field inside the loop, including the angle given above. (Assume that the North pole of a compass, which is held *parallel* to the ground points to the right).

(b) The horses can pull the sliding rail at 8 miles per hour. How large is the voltage generated across the leads to the TV? How much current flows in the circuit? Indicate the current direction on the diagram.

(c) What is the magnetic force on the sliding rail? Indicate the direction on the diagram.

(d) How much power is expended by the horses? How much electrical power does the TV use?

(e) The farmer is probably not very impressed by the numbers. She therefore considers different ways to improve the set up in order to reach a voltage of 120 V. She asks for your help on each of the following ideas:

- She wants to let her horses run back and forth (with the same maximum pulling speed). Would this increase the induced voltage difference? Would a steady voltage be generated (why/why not)?
- She wants to buy new horses which can pull faster. How fast would these new horses have to pull to generate the desired 120 V (keeping the other parameters as before)? Is this speed feasible?
- She wants to add more coils (and sliding rails) of the same size to the set-up. Would this increase the induced electromotive force? If so, how many loops would the farmer need to generate the desired 120 V (keep the other parameters the same as in the original set-up)?
- She thinks about using longer conductors. Which of the two sides in the original set-up (see diagram, the 25 m or the 15 m side) would she need to extend to increase the induced electromotive force? How long would this side have to be to generate the desired 120 V (keep the other parameters the same as in the original set-up)?
- The farmer has heard that the earth's magnetic field changes over the years. By which factor would its magnitude have to increase to generate the desired 120 V (as before, keep the other parameters the same as in the original set-up)? Do you think such an increase is probable? Should the farmer wait for such an increase to happen?

What do you think about the whole project including the ideas for improvements? Would you encourage the farmer to pursue it? Could she use it for other devices in his home (e.g. a 9V charger for his cell phone)? Why or why not?