

Name, School and Contact Information:

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Plan Category:

Physics (grades 9-12)

Title of Plan:

Magnet Car Contest

Objective:

This lesson provides students with a fun and challenging hands-on activity where they apply some of the principles of electricity and magnetism they learn in a typical physics or physical science course. The competitive nature of the activity provides additional motivation, and the process of building and testing their design ideas gives students practice in teamwork and problem-solving.

In the Magnet Car Contest, two-student teams build a homemade model car run by a DC motor and carrying a homemade DC electromagnet. Their goal is for their "magnet car" to travel 5 meters along the floor as quickly as possible, while attracting and pulling paper clips with it across the finish line. Each car is scored based upon the number of paper clips it picks up, and the time it takes to travel.

Required Equipment/Materials:

The teacher needs to provide the motors for uniformity and fairness. The teacher will also need paper clips, a stopwatch, a meter stick, and masking tape for the competition. All other materials can be provided by the students. Students use any materials they can find for their homemade cars – typical materials include K'nex, Legos, and balsa wood. Pulleys on the motor and axle, connected by a rubber band, provide a good way to propel the car. Thin wire around a thick nail or bolt creates the electromagnet. The teacher may wish to make some additional materials available to students that may not be easily acquired – specifically battery holders, wire leads with alligator clips, switches, magnet wire, and pulleys.

Associated Cost:

The motors can be purchased for about \$25 for a class of 30 students. The additional materials can be purchased for about \$50 for a class of 30 students. They can be purchased from school supply sites such as Kelvin.com or local stores such as Radio Shack.

Instructions for Execution:

- (1) Review and familiarize yourself with the rules shown below.
- (2) Two to three weeks before the competition, have students form teams, explain the contest to them, and review the rules shown below. Provide each team with a motor and any other materials you have chosen to provide. If you have done the contest before, it is helpful to the students to show them photos of previous cars.

(If you haven't done the contest before, you can show them photos from my classes at <https://www.tracy.k12.ca.us/sites/whs/whssea/images/magnet/album1.html>)

MAGNET CAR CONTEST

Objective: Build a model car run by a DC motor and carrying a DC electromagnet, that will travel 5 meters, pulling the most paper clips with it across the finish line, in the least amount of time.

Rules:

- Work in teams of 2 students.
- The only source of propulsion will be a single DC motor provided by your teacher.
- Both the car and the electromagnet must be homemade.
- You may NOT use toy/RC cars or parts of toy/RC cars (other than the wheels). You may NOT use permanent magnets. Any other materials may be used.
- Both the motor and electromagnet must be powered by no more than six 1.5-Volt cells (size D, C, AA, or AAA). All cells must be attached to the car (no external wiring).
- The motor and electromagnet must both operate on a switch, so they can be turned on or off.
- You may not use rechargeable batteries or battery packs. The car may not be remote controlled.
- No part of the car may touch the floor except the wheels.
- The paper clips must be pulled by magnetic force, not pushed or hooked.
- Cars will be impounded at the start of the period – you may not work on your car during class.

Scoring:

Score = 10x(Paper Clips) – Time

Time will be measured in seconds. For a paper clip to count in the score, it must be pulled across the finish line by the electromagnet, not pushed or hooked by the car. 20 paper clips will be placed on the floor near the starting line by the team. The paper clips must be spaced at least 1 cm apart. The score will be zero if the car does not travel the full 5 meters (but credit will still be given for completing the project).

(3) Allow 1 class period for the contest. On the day of the contest, mark off a 5-meter "track" on the floor with masking tape. At the start of the period, collect all the magnet cars in one location, and check that they meet requirements (especially make sure all parts of the car are higher than a paperclip thickness off of the ground). Then test each team, one at a time. Give the team 20 standard size paperclips, and let them place the clips where they want, as long as the clips are at least 1 cm apart. Have the team place their car behind the starting line, turn on the motor and electromagnet, and release it when you say go. Time the trip from start to finish. After the car crosses the finish line, turn it off, and turn the electromagnet off. Check to see that the paper clips are no longer attracted to the electromagnet. Count the paper clips that crossed the finish line. Calculate the score as shown above.

(4) You may wish to use a grading method for this activity that incorporates the contest scoring. For example, after a contest like this, I give the highest scoring team a grade of 100%, and the lowest scoring team a grade of 70%. All other teams are graded based on their location between the high and low scores. Grading like this gives students additional motivation to make the best car they can make, but also provides a "safety net" for students who have trouble with the activity.

Measurement of Success:

This lesson is easily assessed. Students are successful if they build a magnet car that can travel the 5-meter track, and can pick up one or more paper clips. In doing this, they demonstrate an understanding of several physics concepts: how an electromagnet is made and works; how a DC circuit is connected and used; and how energy is transferred – from one object to another mechanically, and from one form to another (electric to mechanical, electric to magnetic).

