

Magnetic Levitation – Division C

1. DESCRIPTION: Competitors may construct up to two self-propelled **magnetically levitated** vehicles powered by batteries that turn up to two propellers and move the vehicle down a magnetic track while pulling a maglev sled. Competitors must collect data and develop a graph showing the relationship between the mass being pulled and the time required to reach the finish line. Competitors must also be tested on their knowledge of magnetism and related topics.

A TEAM OF UP TO: 2 **-EYE PROTECTION:** #1 **IMPOUND:** Yes **APPROX. TIME:** 50 minutes

2. EVENT PARAMETERS:

- a. Prior to the competition, competitors must develop data charts and graphs to help them determine how quickly their car can travel to the finish line while pulling the mass of a maglev sled.
- b. The vehicle(s), a copy of the data table and graph, and any equipment required by the competitors must be impounded prior to the start of competition.
- c. The mass of the maglev sled must be a minimum of 50 grams and a maximum of 400 grams (in increments of 50 grams for Regionals, 10 grams for States, and 5 grams for Nationals). The exact mass of the maglev sled must be announced **by the Event Supervisor** after impound has been completed.
- d. All reference materials for the test portion of this event must be secured in a 3-ring binder, must be 3-hole punched and inserted in the binder so that regardless of orientation none can fall out.
- e. **Competitors must wear eye protection during set-up and testing of their vehicles. They may remove it for part 2 of the competition. Teams without proper eye protection must be immediately informed of that, and given a chance to obtain eye protection if time allows, otherwise not be allowed to compete in part 1.**

3. CONSTRUCTION:

- a. Vehicles may be made of any material chosen by the competitors, but must meet all specifications.
- b. The length of the car must not be any less than 10 cm and must not exceed 18 cm.
- c. The part of the vehicle that floats below the side rails of the track must fit on a standard maglev track **and is recommended to be designed with removable width to accommodate track variations (e.g. shims, thick tape, etc).**
- d. **The vehicle, except for the propeller(s), must not extend outside of the vertical planes defined by the side rails of the track.**
- e. The material chosen for the vehicle must not damage the track in any way.
- f. The mass of the vehicle (including batteries) must be no less than 200 grams.
- g. The car must not change in length during its run.
- h. The vehicle must tow a maglev sled behind it (this sled must be provided by the event supervisor). Competitors must secure a screw eye (1/8" or larger) to the rear of their vehicle to allow the maglev sled to be attached. The length of the vehicle specified above includes the screw eye. See the following web page: <http://www.newyorkscioly.org/SOPages/COTResources.html>
- i. **Only commercial batteries, not exceeding 9 Vs, must be used to power the car. The maximum voltage of any circuit in the vehicle must not exceed 9 V.** No other energy must be stored or used in the running of the car.
- j. The batteries must power up to two propellers **and a maximum of two motors** affixed to the car.
- k. Any magnets except rare earth magnets may be used on the vehicle, but competitors must be able to modify the placement of the magnets so that the car can travel in either direction on the track. There is no limit to the number of magnets that may be used.
- l. The vehicle **must be designed to not intentionally physically contact any part of the track.**

4. THE TRACK:

- a. The track, **provided by the Event Supervisor**, must be a standard maglev track (**available from science teacher supply websites, or built using plans available on the Mag Lev event page on soinc.org**) as used in technology classes with a length of 2.4 m and a vehicle track dimension of 2 9/16 inches (~6.5 cm +/- 2 mm).

- b. The height of the side rails of the track must be between 3.175 cm and 5 cm.
- c. The track must be placed on a flat surface such as a table with enough room to allow a cushioned barrier to be placed 28 cm beyond the end of the track to prevent the vehicle from falling to the floor or colliding with something that will cause damage to the vehicle.
- d. The track must not be electrified in any way.

5. THE COMPETITION:

a. Part I:

- i. At the end of impound, the Event Supervisor must announce which direction the vehicles must travel on the track (either the right side must be the north seeking pole or the left side must be the north seeking pole). Note: the north seeking pole is the one that points to the Earth's north magnetic pole when suspended by a string.
- ii. Competitors must have 5 minutes to orient their vehicle to travel in the correct direction on the track, **check for appropriate clearance along the length of the track, remove or add shims from their vehicle if necessary**, attach the maglev sled to their vehicle using the screw eye at the rear of their vehicle (the maglev sled must have a length of 10.15 cm or less), and make two runs on the track.
- iii. Before the first run the competitors must predict their vehicle's Travel Time. They may not change the prediction for the second run.
- iv. Competitors must place their vehicle and the sled on the track behind a line 30.5cm from beginning of the track. They must place a pencil on the line in front of their vehicle to keep it from moving.
- v. When ready competitors may turn on their motor and indicate to the judges that their vehicle is ready.
- vi. Competitors must not touch their vehicle after they have turned on their motor.
- vii. **Judges are strongly encouraged to use photo gates for the timing. If manually timed, Event supervisors are strongly encouraged to utilize 3 independent timers on all runs. The middle value of the 3 timers must be the officially recorded time. Times must be truncated to the tenth of a second. If the stop watch shows a hundredths digit it must be ignored / 'dropped'.**
- viii. The judge must give a countdown of "3, 2, 1, launch". The competitors may then release their vehicle by removing the pencil and step back from the track. At the same time the judge must start the clock.
- ix. The judge must stop the clock when the front of the vehicle crosses the end of the track. If a photogate is used the pencil must be placed behind the line to avoid triggering the photogate in advance.
- x. Both runs may be done with one vehicle or competitors may use different vehicles for each of the two runs. The second run must count as long as it is started before the 5 minute period has expired.
- xi. If a vehicle fails to move after 5 seconds competitors must be allowed to restart their vehicle with no penalty. They must be given one restart during the competition. If the vehicle fails to move on the restart their car must be judged a "did not finish" for that run.
- xii. Vehicles judged "did not finish" for both runs must be given a Run Score and a Prediction Score of 0.
- xiii. If a car moves only part of the way down the track and stops it must be judged a "did not finish" for that run. The distance it moved must be measured.
- xiv. If during the first run any part of the vehicle falls off, the run must be scored as a 0. The team **must be allowed to** attempt to repair their vehicle and make a second run.
- xv. Teams may remove their vehicle from impound once their two runs are completed. Teams may not file an appeal **regarding Part I** after they have taken their vehicle from impound.

- b. Part II: Teams must be given a set amount of time (20 – 30 minutes is suggested) to complete a written test. All answers are to be provided in SI units with proper significant figures. The following topics may be included:

- i. **Magnetism and magnetic fields (field lines, polarity, Earth's magnetic field, magnetic declination, charged particles moving through a magnetic field)**
- ii. **Magnetic force**
- iii. **Electric motor and generators, uses, and parts.**
- iv. **Magnetic field around a long, straight wire, Ampere's Law**
- v. **Magnetic fields of current loops, solenoids, applications of solenoids, common uses**

- vi. **Magnetic domains, permanent magnets, paramagnetic, diamagnetic, ferromagnetic materials**
- vii. **History of the development of theories of magnetism and magnetic technology**
- viii. **Common uses of magnets**
- ix. **Medical uses of magnets**
- x. **The physics of superconductors and common applications**
- xi. **Superconducting Maglev Transportation Technology, including both historical and current projects around the world**

6. SCORING:

- a. **A scoring rubric is available on the event page on soinc.org**
- b. Run Score: The team with the fastest time receives 50 points. All other teams receive points determined by the following formula: Run Score = (fastest time recorded for all teams/ team's fastest time) X 50
- c. Prediction Score: Prediction Score = ((Predicted Time - |Predicted Time – Travel Time|)/Predicted Time) X 30. The Travel Time used must be the time of the fastest run.
- d. Graph Score: Competitors must turn in one sheet of paper with the data they have collected arranged in a table and a graph that is derived from that data. This sheet must receive points as follows: 5 points for a completed data table, 5 points for a graph, 5 points if the graph matches the data table, 5 points for correct labeling: title, team name, x & y axis variables, & increments its units.
- e. Test Score: The test used for Part II of this event must be worth 100 points
- f. Final Score: The final score for each team must be determined as follows:

$$\text{Final Score} = \text{Run Score} + \text{Prediction Score} + \text{Graph Score} + \text{Test Score}$$
- g. Tie Breakers: 1st - fastest Run Score, 2nd - highest Test Score, 3rd - best Prediction Score, 4th - farthest distance traveled, 5th - the mass of the car (lighter car wins).
- h. Tiers: Teams must be ranked in the following tiers:
 - i. Tier 1: Meet all construction requirements and complete at least one run in two attempts.
 - ii. Tier 2: Meet all construction requirements but fail to complete at least one run intact.
 - iii. Tier 3: Fail to meet construction requirements and complete at least one run.
 - iv. Tier 4: Fail to meet construction requirements and do not complete at least one run.
 - v. Tier 5: Fail to impound.

Science Olympiad would like to acknowledge the inventors of Superconducting Maglev Transportation Technology, Gordon P. Danby, Ph.D. and James R. Powell, Ph.D.

2012