

Magnetic Levitation

1. DESCRIPTION: Competitors may construct up to two self-propelled **magnetically levitated** vehicles powered by batteries that turn up to two propellers to move the vehicle down a magnetic track while pulling a maglev sled. Competitors must collect and graph data showing the relationship between the mass pulled and the run time. 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:

- 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.
- 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.
- The mass of the maglev sled must be a minimum of 50 grams and a maximum of 200 grams (increments of 50 grams for Regionals, 10 grams for States, and 5 grams for Nationals) for Division B and 400 grams for Division C. The mass of the sled must be announced **by the supervisor** after impound is finished.
- 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.
- Competitors must wear eye protection during set-up and testing of their vehicles only. Teams without proper eye protection must be immediately informed and given a chance to obtain eye protection if time allows. If not, teams are not allowed to compete in Part 1.**

3. CONSTRUCTION:

- Vehicles may be made of any material, but must meet all specifications and cannot damage the track.
- The length of the car must be no less than 10 cm and no more than 18 cm and cannot vary during the run.
- The mass of the vehicle (including batteries) must be no less than 200 grams.
- The vehicle must fit on a standard maglev track (2 9/16" wide) **and is recommended to be designed with removable width to accommodate track variations (e.g. shims, thick tape, etc).**
- The vehicle, except for the propeller(s), must not extend outside of the vertical planes defined by the side rails of the track.**
- The vehicle must tow a supervisor-provided maglev sled (up to 10.15 cm long) behind it. 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.
- Only commercial batteries 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.
- The batteries must power up to two propellers **and a maximum of two motors** affixed to the car.
- 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.
- The vehicle **must be designed to not intentionally physically contact any part of the track.**

4. THE TRACK: More information provided on the event page on soinc.org

- The track, **provided by the event supervisor**, must be a standard, non-electrified maglev track with a length of 2.4 m and a vehicle track width of 2 9/16 inches (~6.5 cm +/- 2 mm).
- The height of the side rails of the track must be between 3.175 cm and 5 cm.
- The track must be placed on a flat surface with enough room to allow a cushioned barrier to be placed 28 cm beyond the end of the track to prevent the vehicle from being damaged.

5. THE COMPETITION:

- Part 1: Vehicle Testing
 - At the end of impound, the Event Supervisor must announce the direction the vehicles must travel on the track (either the right side or the left side must be the north seeking pole). **The north seeking pole points to Earth's north magnetic pole when suspended by a string.**
 - Competitors must have 5 minutes to orient their vehicle to travel on the track, **check for appropriate clearance, adjust shims from their vehicle**, attach the sled, and make two runs on the track.
 - Before the first run the competitors must predict their vehicle's travel time and cannot change it.
 - 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 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 stepping away from the track. The judge will start the timer.
- ix. The judge must stop the clock when the front of the vehicle crosses the end of the track.
- 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 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 1** after they have taken their vehicle from impound.
- b. Part 2: Written Test: **All answers must be provided in SI units with appropriate significant figures.**
 - i. Teams must be given a set amount of time (20 – 30 minutes is suggested) to complete a written test.
 - ii. **Topics that may be included in either division include polarity, Earth's magnetic field, electromagnetic principles, creating and operating an electromagnet, magnetic vs. nonmagnetic materials, shapes and types of magnets, common uses of magnets, using a compass to determine directions/poles of a magnet, the history of the development of theories of magnetism and magnetic technology, and Superconducting Maglev Transportation Technology, including both historical and current projects around the world.**
 - iii. **Additional topics that may be included in Division C include magnetic fields and field lines, magnetic declination, magnetic force, electric motors/generators, solenoids, magnetic domains, permanent magnets, ferromagnetic materials, medical uses of magnets, and superconductors.**

6. SCORING: High Score Wins. A scoring rubric is available on the event page on soinc.org

- a. Run Score (RS): The team with the fastest time receives 50 points. All other teams receive points determined by the following formula: $RS = (\text{fastest time recorded for all teams} / \text{team's fastest time}) \times 50$
- b. Prediction Score (PS): $PS = ((\text{Predicted Time} - |\text{Predicted Time} - \text{Travel Time}|) / \text{Predicted Time}) \times 30$. The travel time used must be the time of the fastest run.
- c. Graph Score (GS): Competitors must turn in one document with data they have collected arranged in a table and graph that is derived from that data. This document must be scored as follows: completed data table (5 points), graph (5 points), graph matches data table (5 points), and correct labeling, including title, team name, x & y axis variables, & increments its units (5 points)
- d. Test Score (TS): The test used for Part 2 of this event must be worth 100 points
- e. Final Score (FS): The final score for each team must be determined as follows: $FS = RS + PS + GS + TS$
- f. Tie Breakers, in order: Highest RS, Highest TS, Highest PS, farthest distance, mass of car (lighter wins)
- g. 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.