P5 1 NASLEV

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Abstract

We have designed a theoretical magnetically levitated (mag-lev) NASCAR to see how it would compete on several NASCAR tracks. Our car performed poorly on each track, achieving a fastest average lap speed of 52 mph, compared to the official NASCAR record on the same track of 100 mph. The car's underperformance comes from the lack of grip that allows a car to steer, meaning it can only travel at one fixed speed. Performance could be drastically improved by including a turning mechanism such as a guide rail similar to ones used in current mag-lev trains.

Introduction and Setup

This paper will compare the performance of a theoretical mag-lev car against several lap records across multiple NASCAR tracks. We will model our NAS-lev car as a charged particle with charge, q and mass, m travelling around a banked track. The NASCAR engineers have installed a series of underground wires running parallel to the track, such that a current, I can be induced in the wires. This current will produce a magnetic field, B around the wires, such that the magnetic field at the car is pointing across the track, perpendicular to the direction of motion and the current. The current in the track's wires can be run both clockwise and anti-clockwise, to allow clockwise or anti-clockwise motion. When our car moves along the track with velocity, v it experiences a constant magnetic force, which produces the lift required to overcome its weight. This track and car setup is such that for any velocity the car will levitate as the current in the track can be varied to maintain a constant magnetic force.
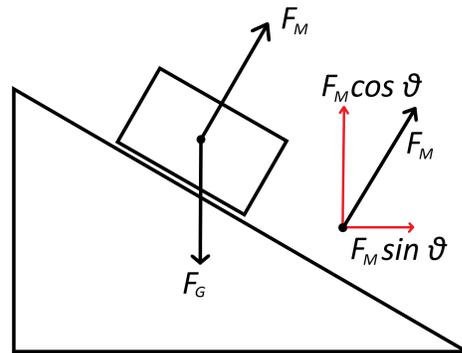

Figure 1: Force diagram showing the forces acting on the car

Theory

Since our car is levitating, it lacks the grip and friction typical of a regular NASCAR car, which prevents it from turning effectively. This means if the car's velocity is too low it will fall into the inside of the corners and if its velocity is too high it will crash into the outside of the corners. We will need to find the velocity that the car needs to travel at such that the car maintains its

position on the track without crashing or moving laterally. Given the mass and charge of the car are constant, the car's on board computer is able to control the value of I such that the the magnetic field produced is the right value for the required magnetic force. Now we can find a general expression for the velocity of the car.

Figure 1 shows the two forces acting on the car; the magnetic force [1], F_M and the weight of the car, F_G defined respectively as

$$F_M = q(\vec{v} \times \vec{B}) \tag{1}$$

and

$$F_G = mg \tag{2}$$

Decomposing the magnetic force allows us to define expressions for these components in terms of F_G and centripetal force, F_C

$$F_C = \frac{mv^2}{r} \tag{3}$$

where r is the turn radius of the track. Now we can write

$$F_M \sin\theta = \frac{mv^2}{r} \tag{4}$$

and

$$F_M \cos\theta = mg \tag{5}$$

where θ is the bank inclination. Rearranging and equating Eq.(4) and Eq.(5) yields

$$\frac{mg}{\cos\theta} = \frac{mv^2}{r\sin\theta} \tag{6}$$

$$v = \sqrt{gr\tan\theta} \tag{7}$$

Eq.(7) gives us the speed we must travel at for any bank inclination and turn radius. What we have derived is the equation for motion around a frictionless banked track [2].

Results

Now that we have a general expression for the velocity of the car in terms of the bank angle and turn radius, we can put it to the test on real NASCAR tracks. We tested our mag-lev car on three speedways and collected track dimensions

Track Name	Turn Radius (m)	Bank Inclination (deg)	NASCAR Record Mean Velocity (mph)	MAGLEV Theoretical Mean Velocity (mph)
Dover Motor Speedway	125	24	161.2	52.3
Martinsville Speedway	55	12	100.5	24.0
New Hampshire Motor Speedway	128	5	127.6	23.4

Figure 2: Table displaying track dimensions, NASCAR lap records and the mag-levs theoretical fastest lap on each track

and NASCAR lap record data for each [3]&[4]. These dimensions were then used to calculate the speed our mag-lev car would have to travel at on each track. The results can be seen in Figure 2. We chose tracks with varying bank inclinations and turning radii but our mag-lev car performed subpar on each track. The NASCAR records are in units of mph as NASCAR measures the highest average velocity in a lap in mph so we have kept that convention. This data, as well as Eq.(7) show that for our car to beat a NASCAR, we would need a very large turning radius and steep banks. The use of mag-lev guide rails (similar to those used by mag-lev trains) could drastically improve the cars performance.

These guide rails would have a feedback loop built into them that constantly adjusts the strength of the induced magnetic field on either side of the car as well as from below to keep the car stable. This would allow the car to turn and reach much higher speeds on the straights and in the corners.

Conclusion

Our simple model of a mag-lev NASCAR would not perform well in NASCAR and performs especially poorly on tracks with tight turns and shallow banks. Our car was far off the lap record on three different tracks that we investigated. For our car to perform well, we would need to give it a turning mechanism or create a very large circular track with a very steep bank.

References

[1] P. A. Tipler and G. Mosca. *Physics for Scientists and Engineers: with Modern Physics.* 6th. Section 26-1. New York, NY: W.H. Freeman, 2008.

[2] LibreTexts. *Motion around a frictionless banked track.* URL: `https : / / phys . libretexts . org / Courses / Georgia _ State _ University / GSU – TM – Physics _ I _ (2211)/05%3A _ Newton's _ Laws _ of _ Motion/5.07%3A_Motion_in_a_Curved_ Path`. (Visited on 11/03/2025)

[3] NASCAR. *Length of Track.* URL: `https : / / www . nascar . com / tracks / #page – summary%20%20%20nascar.com`. (Visited on 11/03/2025)

[4] FRCS. *Bank Inclination & Turn Radius.* URL: `https://frcs.pro/nascar/tracks/`. (Visited on 11/03/2025)