Equivalence Principle Violated
by Dipole Magnets Moving in the Direction of North to South Pole

Robert Francis Jr
me@robertfrancisjr.com
https://robertfrancisjr.com/

Only seven scientists in the public record have conducted magnet free-fall experiments in an effort to determine if they fall at different rates than non-magnetic objects and most contain little hard data beyond visual confirmation. It is claimed that two magnets in a dipole configuration fall faster than a control while two repulsively coupled magnets fall slower. Magnet free-fall experiments using identical rare earth magnets were conducted to test all configurations, NS/NS, NS/SN, SN/NS, and SN/SN, along with a control and measured with a MEMS accelerometer. Results show that the NS/NS dipole magnet in free-fall moving in the direction of north pole to south pole is unique in experiencing progressive acceleration that no other configuration experiences. Average acceleration rates of 11.1509m/s^{2} when dropped from a height of roughly seven feet were recorded while a more compact and aerodynamic shell was tested at the end and averaged acceleration rates of 11.8448m/s^{2}. Gravitational mass tests with a balance show all magnet objects have almost identical mass indicating inertial mass reduction not gravitational mass amplification is taking place.

Keywords: equivalence principle, inertial mass reduction, high-intensity magnetic fields, dipole magnets, solenoid coil

I. Introduction

Out of the seven scientists[1,2,3,4,5,6,7,8] I could find in the public record who have conducted magnet free-fall experiments only one reported testing dipole magnets in free-fall moving in the direction of north pole to south pole in two of his experiments among other configurations. His first experiment showed a slightly shorter free-fall time than the control which was attributed to experimental error and the second experiment showed a slightly longer free-fall time. The magnets used were both N27, one was 19mm OD x 2.57mm thick[2] and the other 25.4mm OD x 4.75mm thick[3] respectively. If the magnets used were N42 but otherwise the same the pulling force would be 7lbs and 27.8lbs respectively.

To add to the public record I tested four different configurations of coupled magnets NS/NS, NS/SN, SN/NS, and SN/SN and a non-magnetic control. An accelerometer measured and recorded the g-forces experienced by all objects during free-fall which were transformed into Meters/Second^{2}. Singularly the NS/NS magnet object experienced progressive acceleration. All other configurations had results close to that of the control object, all plateauing around the acceleration rate of gravity. Gravitational mass experiments found almost no difference in mass and the NS/NS magnet object was not the heaviest which would be unexpected from its free-fall results if gravitational mass modification was responsible for its progressive acceleration rate. Since the writing of this paper I redesigned the free-fall object. I have incorporated the use of a more accurate MEMS accelerometer that has an auto-calibration feature along with shrinking the shell so that the magnetic field more fully encompasses the free-fall object. The redesign of the shell has further increased the acceleration rate of the NS/NS object during tests.

II. Methods

The magnet's used on all magnet objects are RY04X0 neodymium ring magnets from K\&J Magnetics, one of their largest axially magnetized magnet with a hole in the center useful for bolting two magnets in a repulsively coupled configuration. The RY04X0 is an N42 magnet 2" in diameter and 1" thick with a 1/4" hole in the center. It has a pulling force of 205lbs. Four differently configured magnet objects and a control were used in testing, attractively coupled NS/NS and SN/SN and repulsively coupled NS/SN and SN/NS. The first two letters represent the poles of the top magnet while the last two letters represent the poles of the bottom magnet. For example, the NS/NS magnet object's top magnet has the north pole on top and the south pole on the bottom while the bottom magnet also has the north pole on top and the south pole on the bottom facing the ground. AUD stands for Arduino Upside Down indicating the board was flipped inside the shell to determine if the NS/NS results were an anomaly due to the Arduno's orrientation. The control consisted of thirty seven layers of steel fender washers 2" in diameter with a 1/4" hole in the center.

The control and magnet object free-fall portion of this experiment used the following components in conjunction with each object: 3D printed PLA plastic shell 67mm OD x 122.225mm L, milled XPS foam pieces acting as a shock absorber for the magnets and electronics, one 1/4"-20 x 4" long aluminum bolt, two 1/4" aluminum washers, one 1/4"-20 aluminum nut, one Arduino Nano 33 BLE Rev2 with built-in accelerometer, one Adafruit Powerboost 500 Basic, and one 3.7V 250mAh Lipo battery. A cellphone with the app Serial Bluetooth Terminal to receive the recorded data from the Arduino Nano over Bluetooth was used with each trial saved as a text file on my phone for later analysis. The height at which the objects were dropped was approximately 7 feet and each object was dropped a total of twenty five times.

The follow up experiment at the end consisted of testing only the NS/NS magnet configuration. A more compact plastic shell was used measuring 62.55mm OD x 88mm L with less foam encasing the magnets and electronics, one 1/4"-20 x 2.5" long aluminum bolt for easy removal of the magnets, no washers, no hex nut, one Arduino Nano 33 BLE Rev2, one Adafruit BNO055 accelerometer with greater accuracy, self-calibration and built-in conversion to Meters/Second^{2}, one Adafruit PowerBoost 500 Basic, and one 3.7V 250mAh Lipo battery. A wide variety of aft portions of the plastic shell with tapers of 45, 55, 65, and 75 degrees along with no fins, fins of 5mm or 10mm in height and fins 20mm or 25mm long were tested. Tapers of 45 or 55 degrees were found to be the most effective. Each object and tail were dropped a total of fifteen times.

The gravitational mass experiment consisted of using a Bonvoisin Lab Scale analytical balance to record the mass of the four differently configured magnet objects. The components used with each magnet object consisted of one 1/4"-20 x 4" long aluminum bolt, two 1/4" aluminum washers, and one 1/4"-20 aluminum nut with the NSNS and SNSN using the same magnets and aluminum parts just upside down. Thirty layers of approximately 20mm thick XPS foam were used to separate the magnet objects from the analytical balance to eliminate the magnets from altering the results read by the balance. A magnet pole detector was used at the bottom of the XPS foam block to ensure that it was no longer affected by the magnet objects on top of the foam block. The table below represents the average masses from five mass measurements of each component.

III. Results

I have deduced three potential hypotheses for the progressive acceleration seen in the free-fall tests with the NS/NS magnet object moving in the direction of north pole to south pole in FIG. 1 below.

- The NS/NS magnet's field increases its gravitational mass while leaving its inertial mass the same causing it to fall faster than other objects.
- The NS/NS magnet's field decreases its inertial mass while leaving its gravitational mass the same causing it to fall faster than other objects.
- The NS/NS magnet's field both increases its gravitational mass and decreases its inertial mass causing it to fall faster than other objects.

Each magent object is made of the same fundamental components which are nearly identical in mass as seen in the TABLE 1 so each magnet object's mass should be the same if gravitational mass is not being altered which would indicate inertial mass reduction is taking place. On the other hand if the NS/NS magnet object recorded a greater mass than the others then gravitational mass is being altered and hypothesis one or three are the possible explanation.

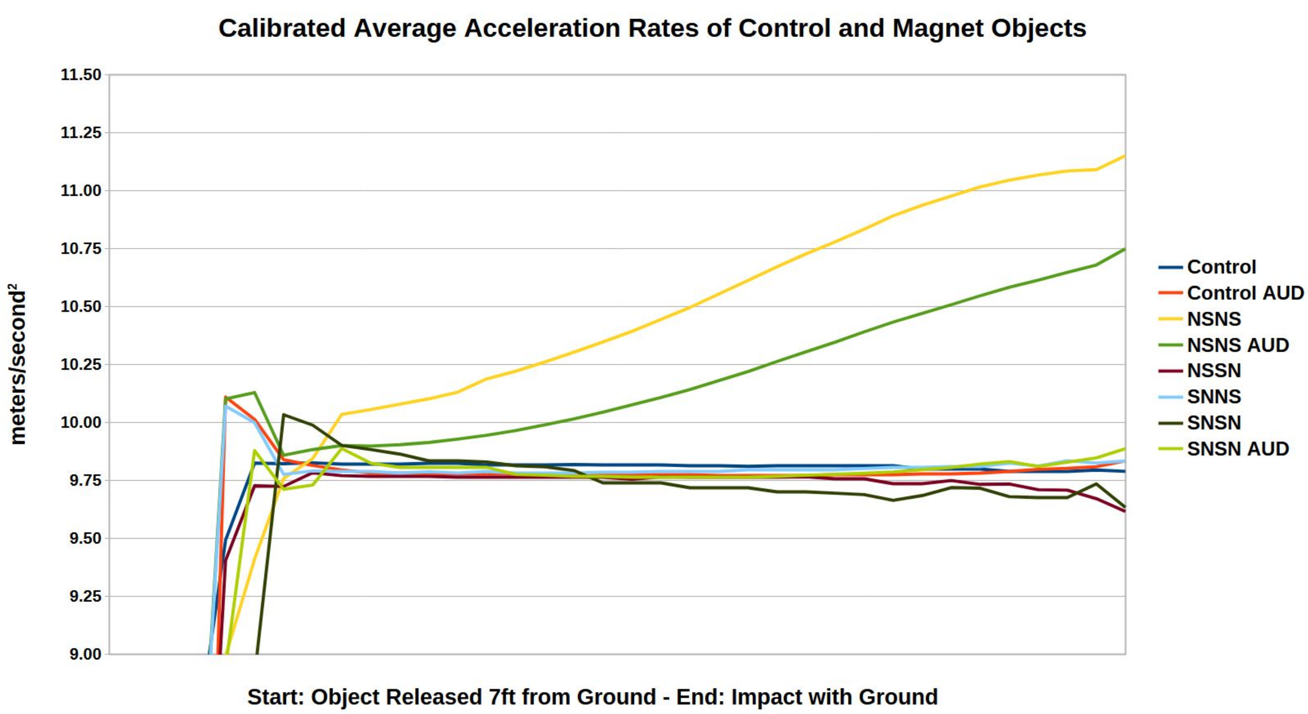

FIG. 1. Each object's acceleration rate in the chart begins when it reached 9 meters/second^2 until it collided with the ground. The acceleration rates were calculated by averaging the thirty-seven snapshots taken by the Arduino's built-in IMU per trial across the twenty-five trials per object. A one point calibration offset was derived and applied from the Control and Control AUD trials subtracting 0.1203 meters/second^2 from regular and 0.3815 meters/second^2 from Arduino Upside Down acceleration rates respectively

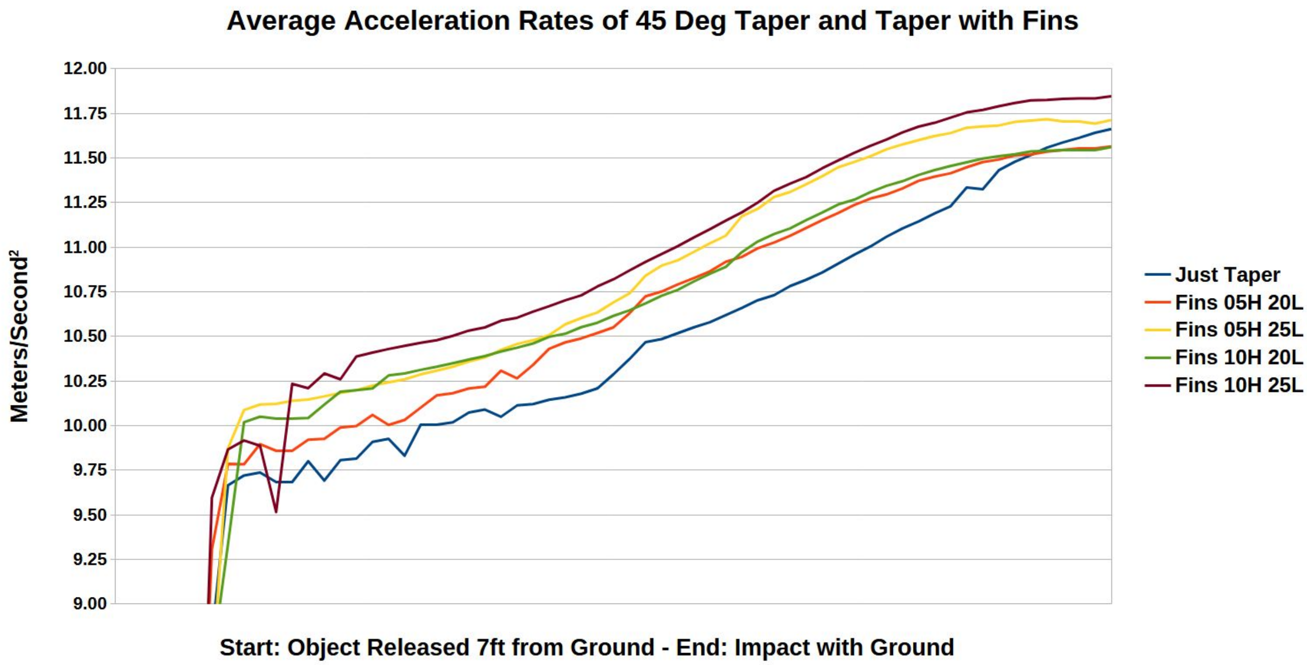

FIG. 2. Each object's tail has a 45 degree taper. Their acceleration rate in the chart begins when it reached 9 meters/second^2 until it collided with the ground. The acceleration rates were calculated by averaging the sixty-three snapshots taken by the BNO055 IMU per trial across the fifteen trials per object.

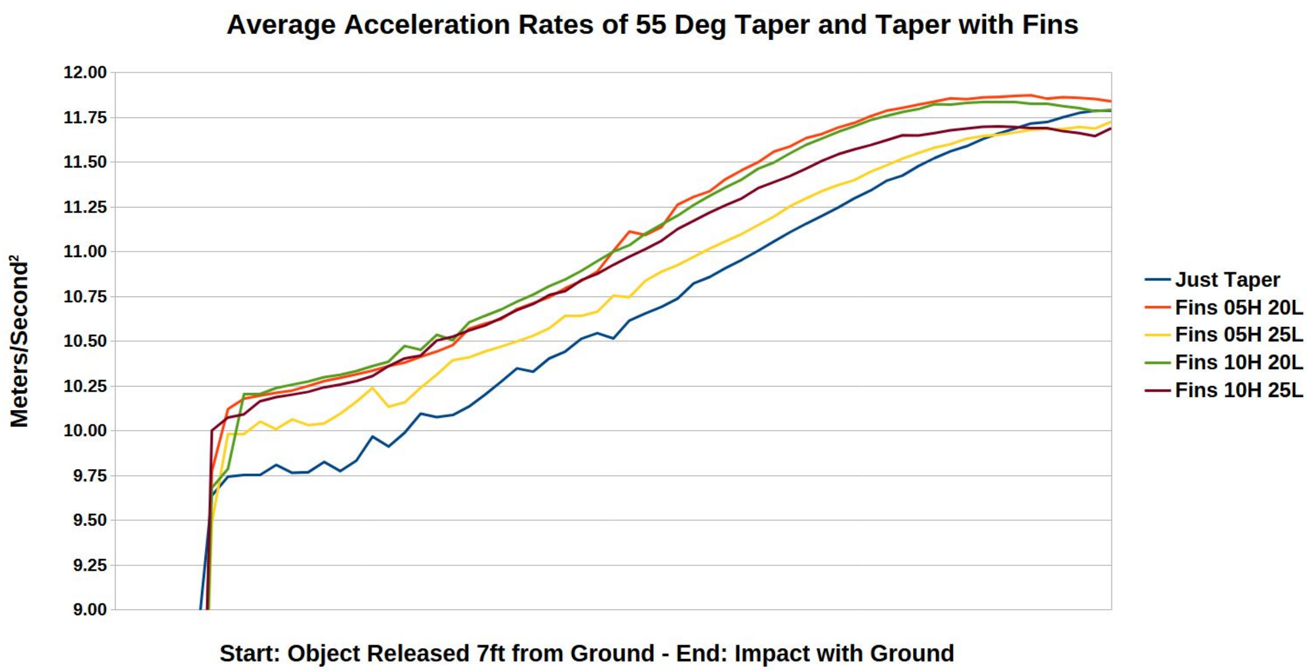

FIG. 3. Each object's tail has a 55 degree taper. Their acceleration rate in the chart begins when it reached 9 meters/second^2 until it collided with the ground. The acceleration rates were calculated by averaging the sixty-three snapshots taken by the BNO055 IMU per trial across the fifteen trials per object.

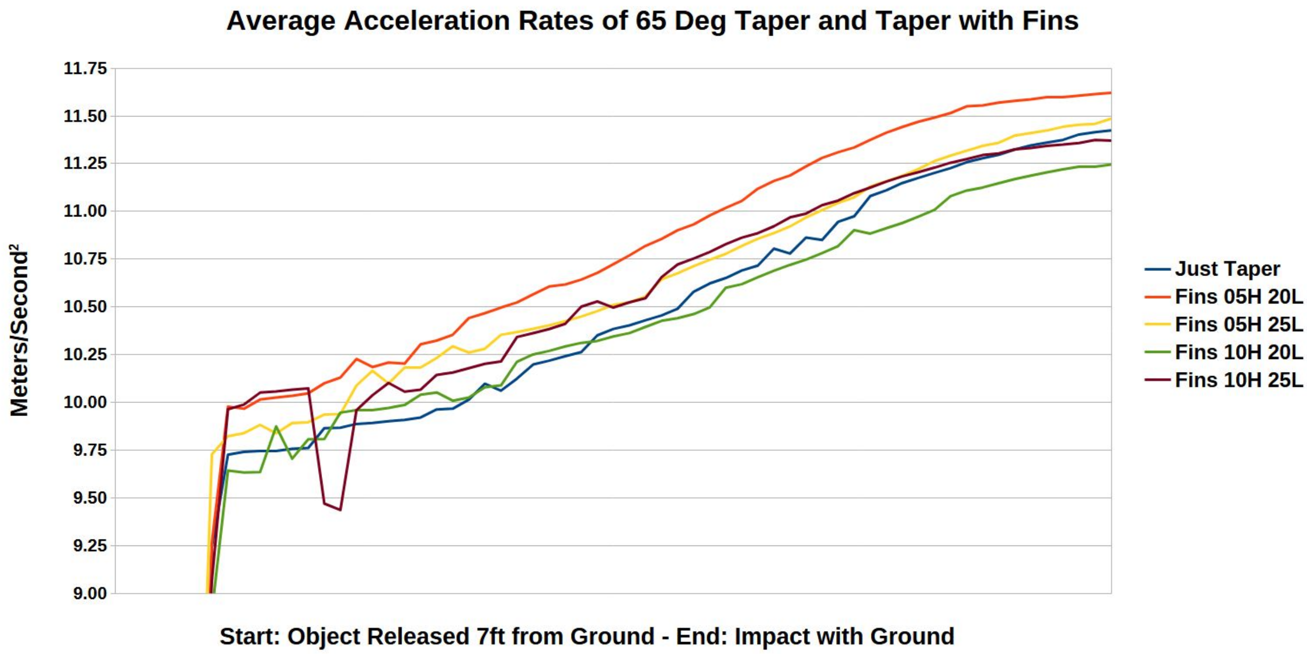

FIG. 4. Each object's tail has a 65 degree taper. Their acceleration rate in the chart begins when it reached 9 meters/second^2 until it collided with the ground. The acceleration rates were calculated by averaging the sixty-three snapshots taken by the BNO055 IMU per trial across the fifteen trials per object.

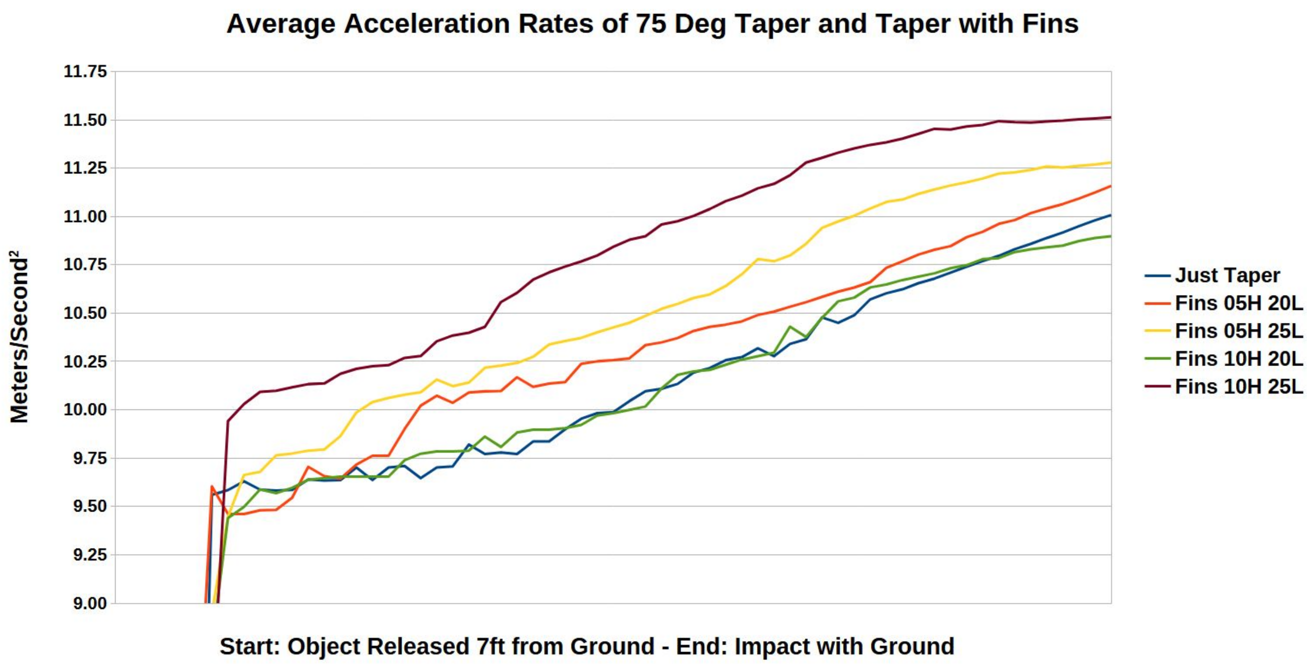

FIG. 5. Each object's tail has a 75 degree taper. Their acceleration rate in the chart begins when it reached 9 meters/second^2 until it collided with the ground. The acceleration rates were calculated by averaging the sixty-three snapshots taken by the BNO055 IMU per trial across the fifteen trials per object.

TABLE 1. Masses in grams of all the parts used in the gravitational mass experiment minus the XPS foam layers separating the magnet objects from the analytical balance.

	NS/NS	NS/SN	SN/NS	SN/SN
Aluminum Bolt	7.642	7.648	7.658	7.642
Aluminum Washers (Qty 2)	1.282	1.318	1.296	1.282
Aluminum Hex Nut	1.136	1.140	1.142	1.136
Reported RY04X0 Magnet Mass (Qty 2)	760.000	760.000	760.000	760.000
Magnet Object Total Mass	771.096	771.094	770.968	771.132

IV. Conclusion

The inertial mass reduction seen with the NS/NS magnet object in free-fall has huge implications for air and space travel. A bar magnet type field as seen in a normal magnet can be replicated with a solenoid type electromagnetic coil as it has a north pole on one side and a south pole on the other. Aircraft and spacecraft with a solenoid coil around its axis of travel moving in the direction of north pole to south pole would experience inertial mass reduction allowing the craft to accelerate at higher rates without the craft and its crew experiencing higher g-forces.

Perhaps inertial mass is a result of matter absorbing virtual gamma rays resulting from the virtual particle electron/positron pairs that are constantly popping into existence and annihilating. The Casimir effect could be interpreted as being a result of virtual gamma ray collisions with the conductive metal plates used in Casimir effect experiments. If the dipole magnetic field put by the NS/NS magnet can interact with the electron/positron pairs before they annhilate they could alter their axis of spin parallel with the field lines of the magnet and when they annhilate the virtual gamma rays don’t collide with the NS/NS magnet, effectively lowering its inertial mass. Regardless, determining that a specific type of magnetic field in motion can reduce inertial mass is a huge step forward in humanity’s technological evolution.

The next steps are two-fold. One is to determine if the acceleration of the tested NS/NS magnet object ever plateaus. It is possible that at some point the acceleration rate of the object plateaus being limited by the field strength of the coupled magnets. Or it might never plateau and stronger magnets and magnetic fields merely increase the rate of acceleration. Conducting free-fall experiments with the NS/NS magnet object from greater heights will give the magnet more time to reach a plateau if there is one. The second is to use guide wires to eliminate any residual rotation of the NS/NS magnet object when being dropped from higher distances to keep the object moving in the direction of north pole to south pole throughout the duration of free-fall.

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