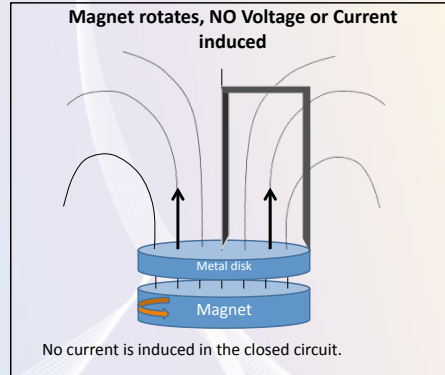
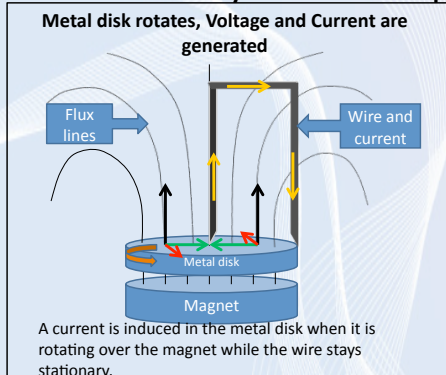


Does an axially-rotating magnet induce an electric field?

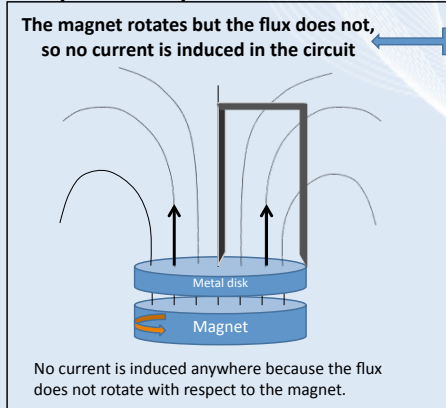
Faculty Mentor: Professors Jim Rabchuk and Kishor Kapale
 Presenting Student: Dustin MacDermott
 Student Participants: Sean Crowe and Chris Fraser

Introduction: Faraday Generator Concept

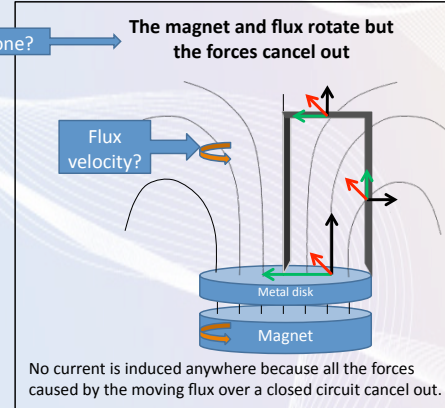


Magnet flux line vector ↑ Flux sees electron moving as vector ↑ Force on electrons ↑ Electron current ↑

Two possible explanations:

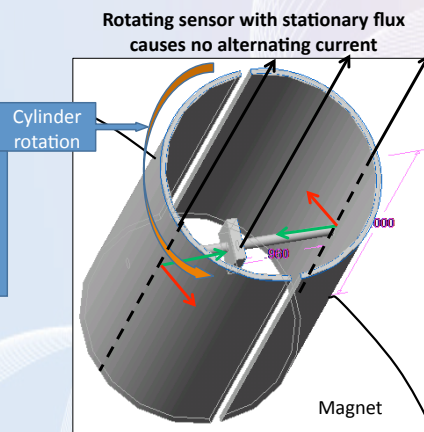
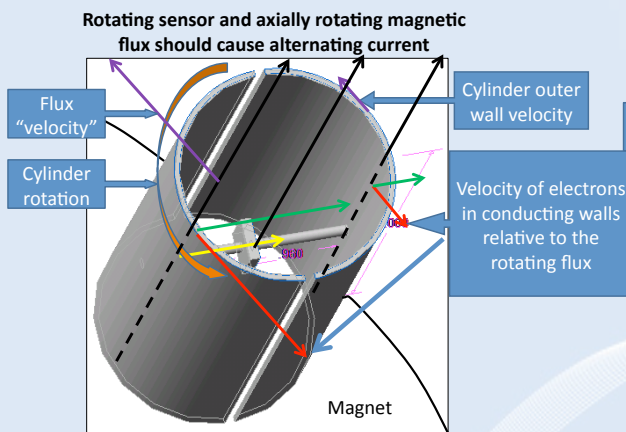


Which one?



Proposed Experiment

Magnet flux line vector ↑ Flux sees electron moving as vector ↑ Force on electrons ↑ Electron current ↑



- The sensor plates are rotated around its central axis and pointed in the direction of the magnetic flux. If the axially orientated flux rotates with the magnet this will induce an **alternating current** in the sensor as shown in the **picture on the left**. If there is **no moving flux** there should be **no alternating current** generated as shown in the **picture on the right**.
- The device detects **current across the center wire**. It also detects the angle of the plates relative to the center axis. This will give us a way to detect the electric field generated by the flux lines crossing along detector plates.
- The alternating current should only occur if an electric field is present or we have changing flux of sufficient magnitude.
- The device is sensitive to an electric field on the order of 10 V/m.
- How powerful of a magnet do we need and how fast do we need to rotate the magnet to see this effect if at all? The answer in short is that we could use a magnet of about 1 Tesla and to rotate it at about 11500 rpm.

Physical Model

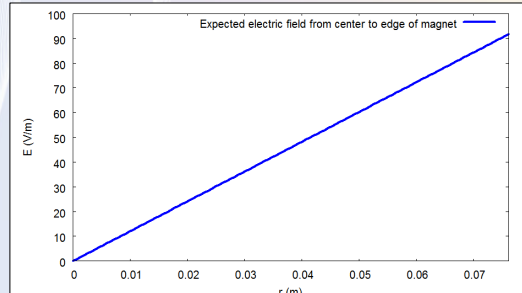
The Lorentz Force Law: $F = q(\vec{E} + \vec{v} \times \vec{B}) \rightarrow E = \text{Electric field (SI unit = Volts, V)}, B = \text{Magnetic field (Tesla, T)}$

$F = \text{Force (Newtons)}, q = \text{Charge value (Coulombs, C)}, \vec{v} = \text{Velocity (meters/second)}$

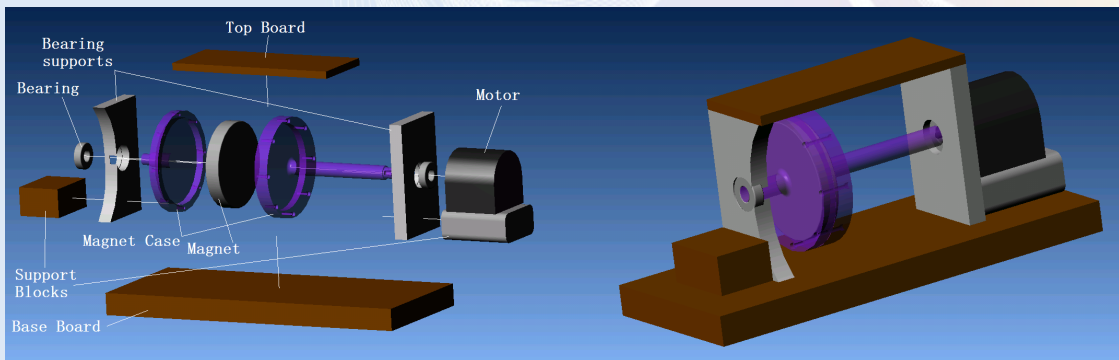
$\vec{v} = \omega \times \vec{r} \rightarrow \omega = \text{radial velocity and } (\vec{r}) = \text{the radius of the flux being sampled by the sensor}$
then (\vec{v}) is what we expect to be the velocity of the flux above the magnet.

$r = 0.075(\text{m}) = 3(\text{in}), \omega = 1,204(\text{rad/s}) = 11,500(\text{rpm}), B = 1(\text{T}) \rightarrow (\vec{v} \times \vec{B}) = E_{\text{eff}} = 90(\frac{\text{V}}{\text{m}})$

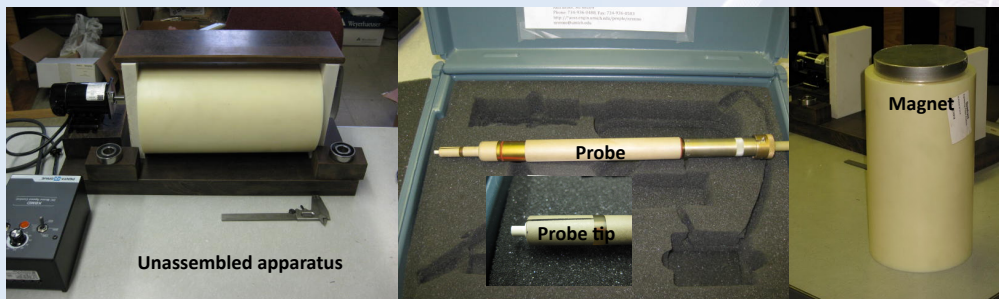
If the magnetic flux does rotate and induce an electric field, the induced electric field should increase linearly with radial distance, and should be directed radially inward toward the center, parallel to the magnet's surface.



Proposed apparatus design for spinning the magnet to high rpm



- The bearings are a hybrid of ceramic balls, plastic cage and stainless steel rails, sealed in grease. The attraction to the magnet is small. The bearings are of low friction and machined to high tolerance for high rpm performance. This is more necessary the larger the radius of the bearings.
- The magnet case and spindle is made out of machined nylon. Dr. Rafael Obregon from the Manufacturing, Engineering and Technology Department is assisting us with machining the nylon case using CAM "Computer Aided Manufacturing" to needed tolerance. Care will be taken to accelerate the magnet softly over time and not cause torque stress. The center shaft is 1 inch thick and later tapers into the bearings.
- The bearing support away from the motor had to be partly cut away to allow probe access to the magnet.
- There 8 holes in the magnet case which will be bolted shut with brass lock tight nuts and threaded shafts.
- The base board has been selected to be heavy for better support.
- The magnet is about 1.3 Tesla at the surface and can lift about 560 lbs.
- The motor support block doubles as a side support for the side board providing extra stability.
- The side boards "bearing supports" have ridges where the holes are for the bearings so the bearings are not allowed to move toward the magnet.



CONCLUSION: According to the Lorentz Force Law, a charge moving in a magnetic field is affected just as it would be in an electric field. But there is an uncertainty in how to interpret the velocity term in this law. The answer is usually the velocity of the charge. This, however, leaves the question of "relative to what" unanswered. If our experiment indicates that there is moving flux causing an electric field, then one could surmise that the velocity vector in the equation above instead represents the velocity vector of the electron as seen by the flux. This result would suggest that electric and magnetic flux concept may be more fundamental to electromagnetism than the corresponding and more well-known fields.