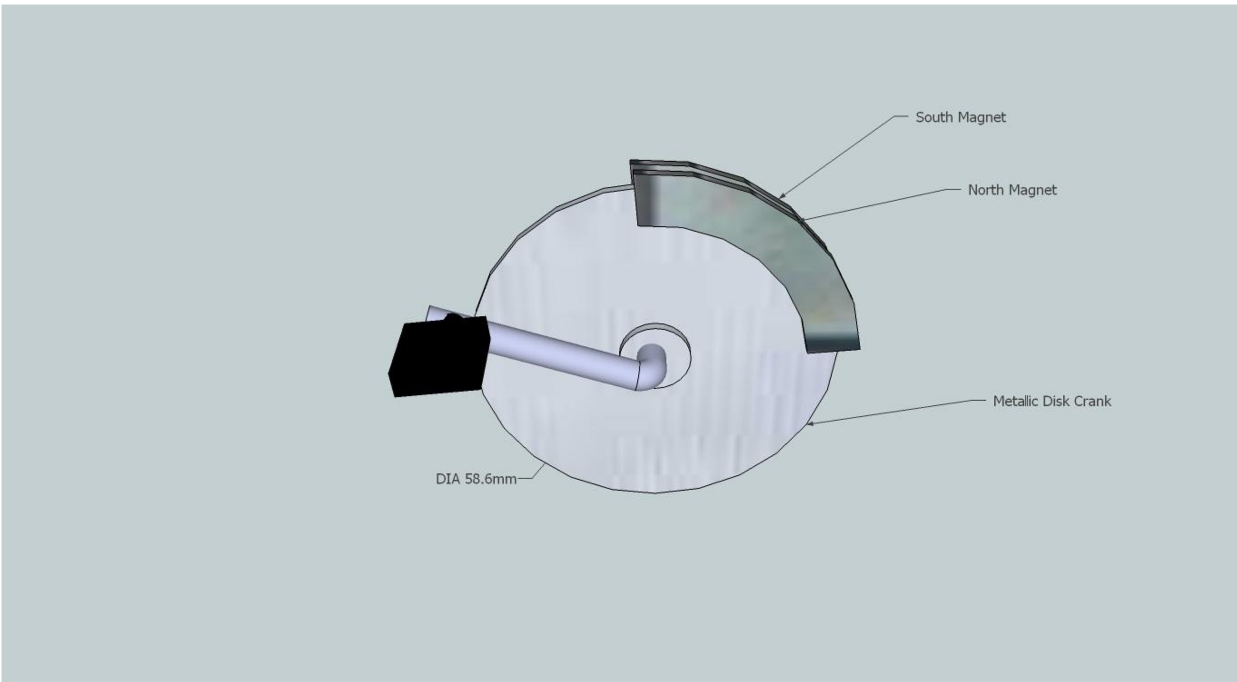
Magnetic Brake Concept

Description: This concept uses Eddy currents on a metallic disk to generate a dragging force on the disk. The disk will be our flywheel, thus, we are creating an opposing force on the pedals to resist movement.



How it works:

- Two magnets, one oriented North and one oriented South, are placed on opposite sides of a metallic disk with flux lines transmitting through the disk.
- When a moment is applied to the crank, via the pedals, the two magnets induce Eddy currents in the skin of the disk. These currents create a resistive force to the direction of motion.
- As the pedals are spun, the disk passes between the magnets. The opposite charge of the magnets creates tiny circular currents in the surface of the disk, called eddies.

Governing Equations:

$$\tau = .37dAr^2\sigma\omega B^2$$

A = Area of Magnetic Pole Face – Meters^2

B= Magnetic Flux Density – Teslas

d = Thickness of Disc – Meters

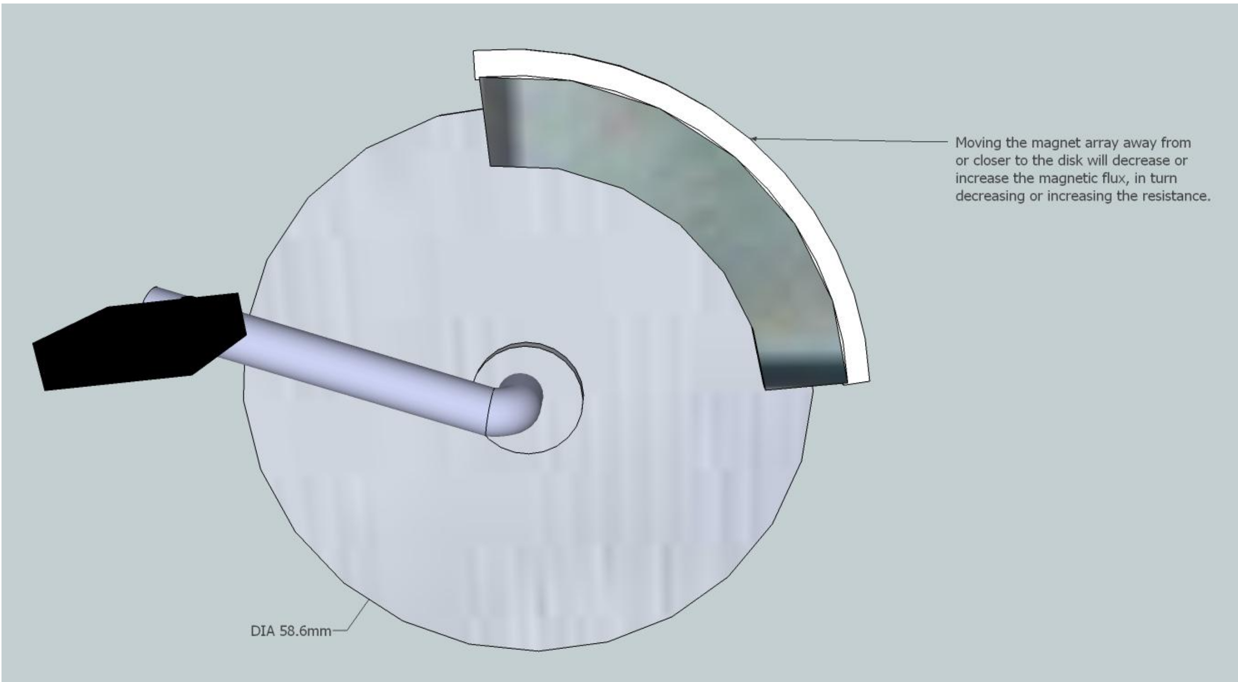
ω = Angular Velocity – Radians/Second

σ =Conductivity of Metal – Siemens/Meter

r = Radial Distance of Pole from Center – Meter

Explanation:

- The torque equation will help us determine what our specs should be for the disk and the magnets such as exact dimensions, number and quality of magnets, and materials.



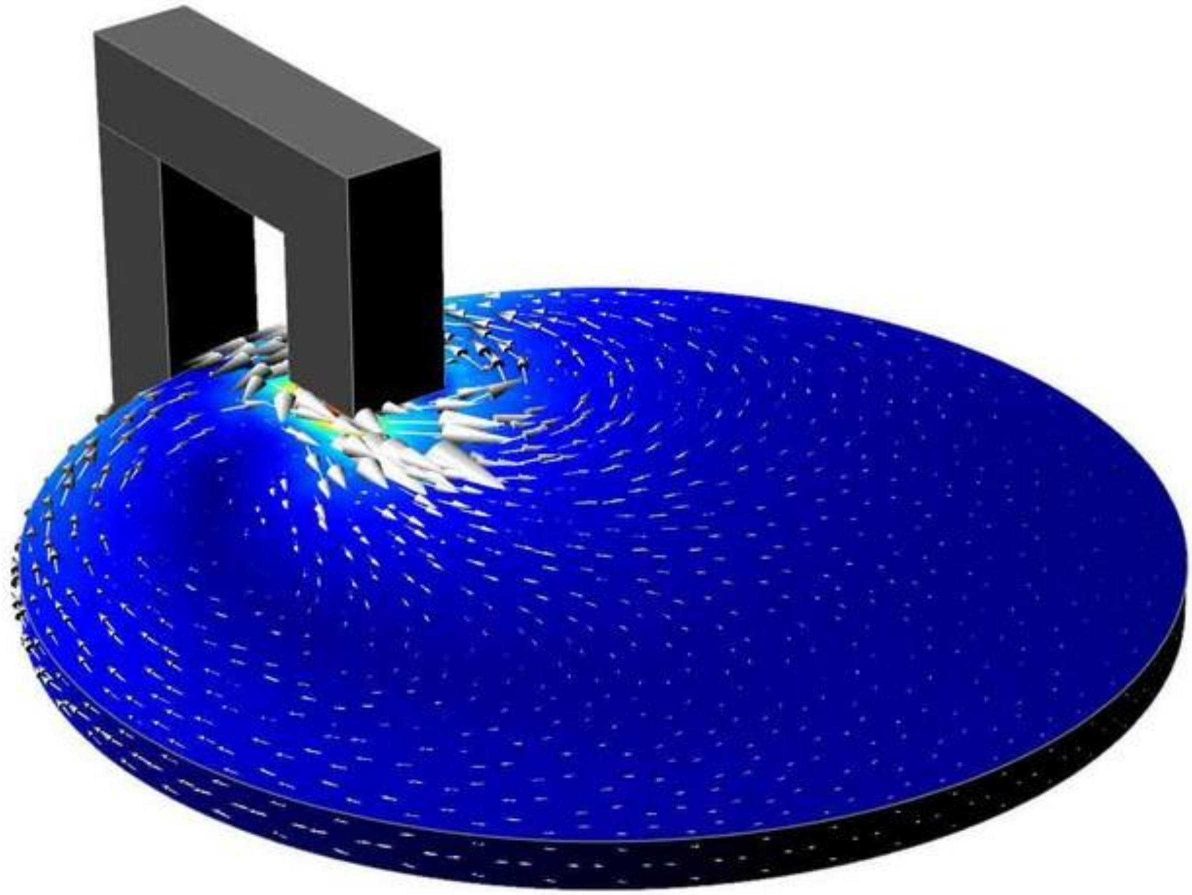
We plan to reuse the current adjustment knob on the friction system to raise and lower the magnet array. This will increase and decrease the flux, and in turn affect the difficulty of pedaling in the same way. With the fine adjustment, the PT should be able to accommodate a wide range of abilities.

Advantages:

- No friction – This means that parts should not wear out or degrade over time.
- Resistance is directly proportional to pedaling velocity so there will be no initial "sticking."
- Wide range – Able to go from free spinning to almost immovable.
- Uses some of the existing hardware
- Maintains the low "step through," as requested by the customer.
- Does not require major frame changes.
- Simple to operate. Very little training required.

Disadvantages:

- Not a theory we are trained in understanding at RIT. Requires additional learning.
- May, possibly, interfere with electronics. (pacemakers?)
- May not be comfortable to use for anyone with metal parts in their legs or feet.
- May interfere with current speedometer. (Works by magnetic interaction)



Eddy Current shown in disk

Mathematical Analysis:

Speed	Radians/s	Torque(N*M)	Force(N)	Delta Target (200 N)
Extremely Slow	9	7.068196792	41.57762819	158.4223718
Quick	27	21.20459038	124.7328846	75.26711544
Fast	45	35.34098396	207.8881409	-7.888140934

Critical Perameters		
Sigma	3.80E+07	S/m
Radius	0.1373	m
Disk Thickness	0.0125	m
Disk Volume	0.000883573	m^3
Density	2800	KG/m^3
Disk Mass	2.474004215	KG
Moment Inertia	0.027832547	KG*m^2
Field Strength	0.31591159	Tesla
Area Covered	0.002375191	m^2
Magnets	3	Pairs
$ per Magnet	9.99	Dollars
Cost	59.94	Dollars

Magnetic Properties of Selected Magnets				
bx	br	t	r	x
0.31591159	1.32	0.03175	0.015875	0.008

Based on the above analysis we determined that the magnet selected (see properties) will work for our application as long as we gear up the spinning aluminum disk to achieve higher rotational velocities. Our example above shows a 1:9 gear-up ratio.

This means that we will not be exactly following the pictures above but rather spinning a crank that will transfer power via a chain to a small gear on the aluminum disk, which will increase the velocity of the disk. The gearing up should not create a difficulty issue as the inertia of the disk is very small.