The manufacture of permanent magnets is a common process. Wrapping wire around an iron nail and sending current through the wire is one method to do this. Although this process seems simple, there are significant theoretical problems when a relativistic analysis is made.

The Experimental Setup
Figure 6 shows a large rod with mass *M* surrounded by two smaller magnets, each with a mass of *m/2*. The smaller magnets are directly opposite each other and each with distance *r* to the large rod mass. The charges on the smaller magnets have the same orientation as shown, while the large central mass has no charge in the beginning of the experiment.

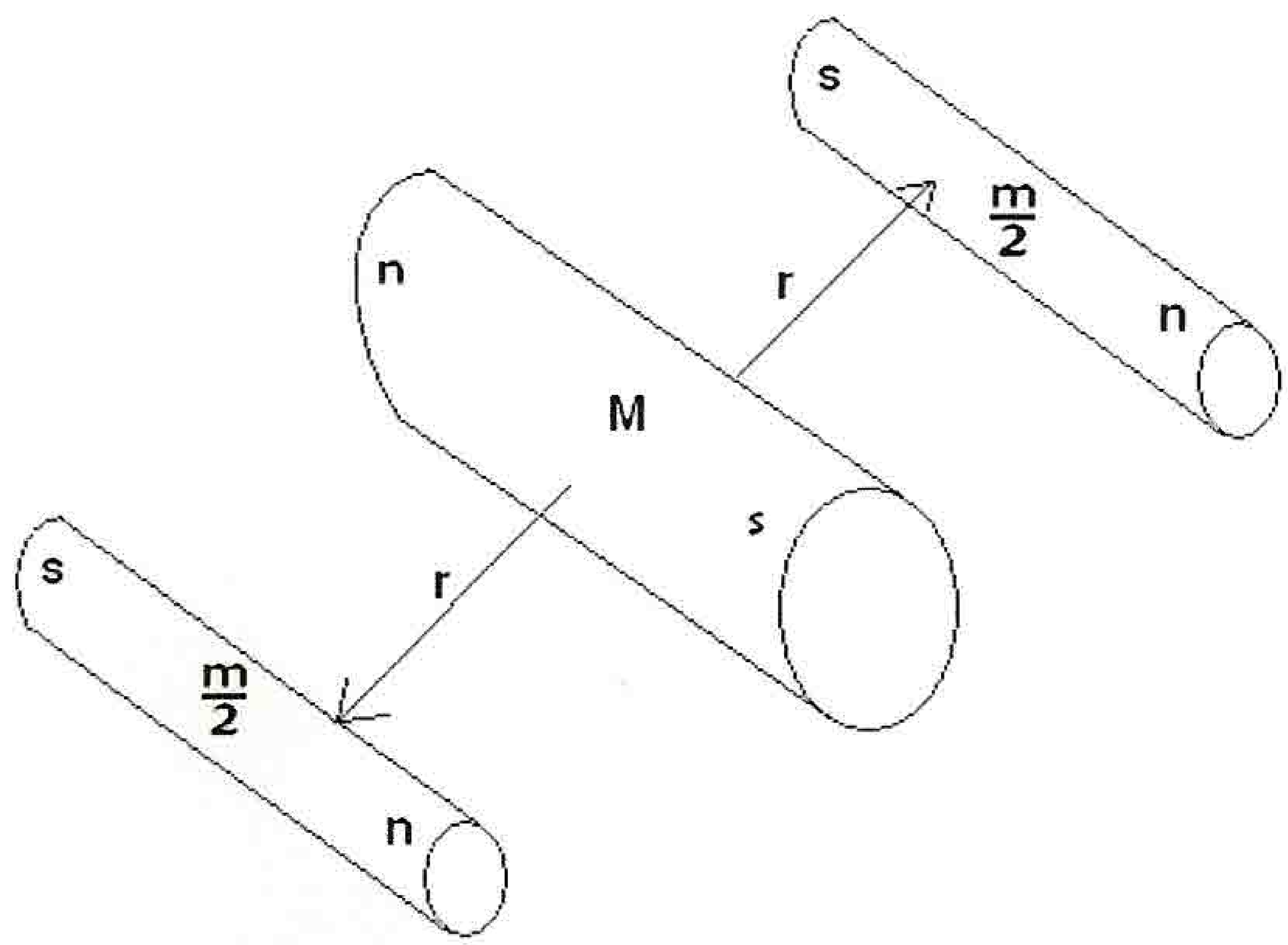

Figure 6. Large central rod mass surrounded by two smaller rod magnets.

Part of the large central rod is a separate rod of material that can be magnetized (iron), and this material is already wrapped with wire connected to a battery for this purpose.

The Experiment
An important part of the above experiment is the force of gravity on the three rods. This force will draw the three rods together over time, so it will be assumed that poles on the central rod hold off the two smaller rods. The governing gravitational equation will be Newton's.

$$F = \frac{Gm_1m_2}{R^2} \qquad (20)$$

F - Gravitational force between two masses

G - Gravitational Constant
m_1, m_2 - the two masses experiencing the force F
R - the distance between the two masses

The gravitational potential energy of the system is:

$$P_g = 2GM\frac{m}{2}\left(\frac{1}{r_2} - \frac{1}{r_1}\right) = GMm\left(\frac{1}{r_2} - \frac{1}{r_1}\right) \tag{21}$$

r_1 is the first radius that the small magnets start with
r_2 is the final radius that the small magnets end up at

The potential energy is positive if the smaller magnets move closer to the central rod.

The magnetic force equation for this experiment is Gilberts equation.

$$F = \frac{Uq_1q_2}{R^2} \tag{22}$$

F - Magnetic force between two "charges"
U - A Permeability Constant = $\mu / 4\pi$
μ - permeability
q_1, q_2 - the two charges experiencing the force F
R - the distance between the two charges

The radial position of the smaller magnets does not affect the magnetic balance of the system as long as both smaller magnets are at the same distance from the large central rod. The two smaller magnets in the experiment will repel each other, but will attract themselves to the iron in the large central rod. The net effect of these magnetic forces will be small compared to the other energies in the experiment, but will still be included.

If E_m is the energy represented by the existing magnetic fields of the two magnets in the system, the total energy of the system is:

$$E_1 = Mc^2 + mc^2 + E_m + P_g \tag{23}$$

At this point, an amount *M'* of the material of the central rod is converted into energy through nuclear fission. This energy is used to drive an electric current through the wire surrounding the iron component. This current magnetizes the iron creating charge q_1 in the central rod with the orientation to attract the smaller magnets as shown in Figure 6. It will be assumed this happens with 100% efficiency, so that all of the fission energy goes into creating the permanent magnetic field within the central rod.

Equation (22) represents the force between one of the created charges and one of the charges on the other magnets in the system. To simplify this analysis, the experiment has been broken up into four experiments. The experiment to be examined will be the n-charge end of the large central rod with the s-charge ends of the smaller magnets. The s-charge end of the central rod will have a similar calculation. Two other experiments also exist, where like n-charges repel each other and like s-charges repel each other. These three other cases will not be presented here. The four experiments should be added together for the total effect, but a single experiment will demonstrate the principle.

The reduction in mass of the central rod reduces the gravitational potential energy of the system. The new gravitational potential energy is:

$$P'_g = G(M - M')m\left(\frac{1}{r_2} - \frac{1}{r_1}\right) \tag{24}$$

The energy E_m will not be affected by the introduction of the new magnet into the system. The effect of the new magnet is superimposed over the existing magnetic effects.

If the two smaller magnets in the system have charges $\frac{q_2}{2}$, a new magnetic potential energy has been added to the system and this energy is:

$$P_m = 2Uq_1\frac{q_2}{2}\left(\frac{1}{r_2} - \frac{1}{r_1}\right) = Uq_1q_2\left(\frac{1}{r_2} - \frac{1}{r_1}\right) \tag{25}$$

The new total energy of the system is now:

$$E_2 = (M - M')c^2 + mc^2 + E_m + P'_g + P_m \tag{26}$$

The Law of Conservation of Energy gives:

$$E_1 = E_2$$

$$q_1 = \frac{M'\left(\dfrac{c^2}{\frac{1}{r_2} - \frac{1}{r_1}} + Gm\right)}{Uq_2} \tag{27}$$

In this experiment, a magnetic potential energy (25) has been added to the system and a gravitational potential energy $GM'm\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$ has been lost. The difference between these two potential energies is made up by the fission energy $M'c^2$.

The Paradox

A casual look at the amount of energy needed to produce a magnetic charge on a piece of iron would seem to indicate that a simple energy conversion process is taking place. It is not surprising to see that q_1 is dependent on *M'*. Even the input of the permeability *U* is a possible contributor to the process. But what are all those "other" terms doing in (27)? Let's clarify (27) by writing it in a more precise form.

$$q_1 = \frac{M'\left(c^2 + \sum_i Gm_i\left(\frac{1}{r_{2i}}-\frac{1}{r_{1i}}\right)\right)}{\sum_i Uq_{2i}\left(\frac{1}{r_{2i}}-\frac{1}{r_{1i}}\right)} \tag{28}$$

The "other" terms in (27) and (28) reveal the fact that the creation of a magnetic charge is dependent on the other objects in the system. Magnetism is not like gravity, which has always been around for every object in the universe. Magnetism is a potential energy field that can be created and destroyed.

If the experiment of Figure 6 is proposed to be a simplified representation of all the bodies in our universe, then the action of creating a magnet by winding a piece of wire around a nail is dependent upon every other mass in the universe and it's position relative to our own. Strangely enough, the mass of the iron nail is of no consequence. It also depends upon the magnetic state of every other mass in the universe, the permeability of the intervening space and the gravitational constant *G*.

The problem with the statement just made is that running a current through a wire that is wrapped around an iron nail doesn't seem like such a grand process. Does it really indicate a significant linkage between relativity, gravity and magnetism on a universal scale? Or is q_1 simply dependent on the electrical energy due to the current in the wire, represented by $M'c^2$?

Putting Numbers into the Equation

To get an idea of the magnitude of the different terms in (28), suppose that:

$$\frac{1}{r_{1i}} \approx 0 \qquad r_{2i} = 1m$$

$$c = 3\times10^8 m/\sec \qquad G = 6.67\times10^{-11} m^3/kg - \sec^2$$

$$\sum m_i = 6 \times 10^{26}\, kg \tag{29}$$

The mass of the earth is about $6 \times 10^{24}\, kg$ so the $\sum m_i$ term in (29) is equivalent to 100 earths. This makes the mass summation term in the numerator of (29) a significant number compared to c^2. But the real mass of all the planets in the universe is much higher than this, making the c^2 term in (28) insignificant. So the $M'c^2$ term in (28) is actually not important in the magnetization of the iron nail, even though this is approximately equal to the electrical energy that flowed through the wire. Instead, what (28) says governs the magnetization process is the mass of planets thousands of light years in the distance, even though these planets won't know about the current sent through the wire for thousands of years after it happens.

One Possible Solution

If fields represent a storage of potential energy and energy has mass (in relativity theory), then fields have mass. This idea has already been presented in the discussion surrounding Figure 20 in the article *Moving Energy Forces* and Figure 11 in the article *Gravity and Energy*. For the example under discussion here, the proposed solution is to realize that the magnetic field created when the iron nail was magnetized has a mass *m'*, which is equal to *M'*.

$$m' = \frac{P_m}{c^2} = M' \tag{30}$$

The mass *m'* has a gravitational field and associated gravitational force *f'*.

$$f' = \frac{Gmm'}{r^2} \tag{31}$$

This gravitational field has a potential energy *P'*.

$$P' = Gmm'\left(\frac{1}{r_2} - \frac{1}{r_1}\right) \tag{32}$$

Recalculating E_2 :

$$E_2 = (M - M')c^2 + mc^2 + E_m + P'_g + P_m + P'$$

$$E_1 = E_2 \tag{33}$$

From (25):

$$q_1 = \frac{M'c^2}{Uq_2\left(\frac{1}{r_2} - \frac{1}{r_1}\right)} \tag{34}$$

Or more generally:

$$q_1 = \frac{M'c^2}{\sum_i Uq_i\left(\frac{1}{r_{2i}} - \frac{1}{r_{1i}}\right)} \tag{35}$$

Equation (35) appeals more to common sense than (27) or (28).

Summary
Magnetic fields can be created or destroyed and this characteristic allows a theoretical analysis that cannot be applied to gravitational fields. An analysis has been presented that shows a link between magnetism and gravity (equations (27) and (28)). This analysis produces results that don't seem to make sense. A solution to this paradox is to assign (relativistic) mass to potential energy fields, a concept that also solves problems in the other articles listed above.