4.9.2008 R. Miller

MagKinetics
General Physics Note 1

I. Overview

Kinetic energy of a moving car is “lost” when the car slows down (at traffic signal/sign, highway off ramp, bridges, hills, mountains). Energy is lost in the form of heat, due to friction in the brakes.

Not only is this idea timely and important for energy reasons, but also as a practical and a safety issue. The proposed system would lessen wear and tear on brakes and improve traction (there is a component of attractive force perpendicular to road which would contribute to the normal force due to gravity. This would be useful on slippery roads, hills/mountains, where “traction”, i.e. friction between car and roads, is lessened due to incline).

II. Energy

As a vehicle decelerates for any of the aforementioned reasons, a portion of the kinetic energy of the automobile, proportional to the effective magnetic force applied, is transferred to kinetic energy of the generator.

Table 1 represents the maximum energy that could be obtained via the magnetic attraction between vehicle and magnets mounted on generator.

The amount of energy extracted is dependent on the amount of magnetic attractive force (parallel to the vehicle’s motion) between car and generator. I report the energy extracted for several values of attractive force. To be as general as possible at this stage, I report the force as a percentage of the frictional force on the car due to the road.

For purposes of these calculations, I will assume that the magnetic force is constant. In reality the magnetic force will not be constant, but rather it will be dependent on the shape of the magnetic fields. I’ll use the “effective” magnetic fields/forces here, and later calculate the fields necessary to give these effective forces.

Also, I assume that the generator will be extracting energy for the entire normal stopping distance of the car. The normal stopping distance will be the distance that a car travels unaided by brakes or accelerator.

Does the car necessarily need to stop?
Distance is not required to be entire stopping distance. In the case of a fast moving car, the magkinetics system probably wouldn’t be the entire stopping distance. For a slower

moving car, system would probably be longer (for car moving 25 mph, stopping distance without braking is ~ 7m).

Table 1.

Velocity prior to deceleration = 30 m/s ~ 60 mph

Magnetic attraction force as a % of frictional force	10%	20%	50%
Stopping distance [m]	46.3	42.5	34
Energy obtained (per car) [J kWh]	71,946 .02	132,082 .037	158,500 .044
× 90,000 cars [kWh]	1800	3300	3960

V = 20 m/s ~ 40mph

Magnetic attraction force as a % of frictional force	10%	20%	50%
Stopping distance [m]	20.6	18.9	15.1
Energy obtained [J kWh]	32,010 .009	58,737 .016	117,320 .033
× 90,000 cars [kWh]	810	1440	2970

V = 11 m/s = 40 kph ~ 22 mph

Magnetic attraction force as a % of frictional force	10%	20%	50%
Stopping distance [m]	6.34	5.8	4.7
Energy obtained [J kWh]	9852 .003	18,025 .005	36,516 .01
× 90,000 cars [kWh]	270	450	900

This energy table will eventually need to be augmented with information about the energy required to power the magnets which are necessary to extract energy from the car.

III. Magnetic Field

For now, assume that magnetic attraction is that due to two dipole magnetic fields. This means that the total work done is that due to one dipole (induced) moving through the magnetic field of another (electromagnet). We first need to calculate the magnetic field of magnets located on generator. Then we need to calculate the dipole moment of the automobile located in the magnetic field of the generator.

Making a few assumptions about dipole moment of the car,

$U \sim (4 \pi R^2) * \chi_m / ((1+ \chi_m)*\mu_0)*B^2$,

where R = 2.5m (roughly half the length of a car).

If we assume that all of the energy stored in the magnetic field will be extracted, and assume B = .1T,

U = 62.5J – 625,000J

I report a range of energy because χ_m, the magnetic susceptibility, is uncertain. Because the car is made up of various materials, some of which are paramagnetic and some ferromagnetic, its magnetic field will be difficult to calculate. Typically the magnetic response of ferromagnetic materials is measured.

If we assume that the car behaves like a paramagnetic material with a susceptibility ~ 1 ×10^-4, the energy available from the magnetic field [.1 T] will be less than 100 J. If the car behaves like a ferromagnetic material with a susceptibility ~ 50, the energy of the magnetic field will be greater than 100,000 J.

Questions:
Geometry of electromagnets
How many magnets
Energy required to power magnets to desired B

IV. Generator

Efficiency of generator
Coil design

V. Safety

Are there eddy currents induced on outside of vehicle? Is there a static charge induced on opposite ends of vehicle, due to the cancellation magnetic field?

VI. Future Developments

With the existence of magnetic fields in roads, it is natural to wonder whether we could generate electricity via coils mounted to car, which could then be used to recharge battery.