# Power Requirements for Levitation in a Gravity Field

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## 1. Introduction

This article will present the idea that energy flow is necessary to support a person sitting in a chair, or any object to be restrained from falling down. This idea came from the effort of riding a bicycle up a hill 35 years ago. It is based on experience, and some empirical evidence will be presented to support it. This idea has deeper theoretical implications. It took long to digest and ferment as I tried to convince myself that it was not true.

A draft of the original essay of 1986 is presented in section 3. Further considerations of a theoretical nature follow that 1986 essay along with experimental evidence, implications, and consequences.

## 2. Background

Consider a boy (or girl) riding a bicycle on level ground with no wind. Effort is required in pedaling to keep moving to overcome friction. If pedaling stops, then the bicycle and rider slowly coast to a stop, or quickly decelerate, depending on friction. Friction to the ground is created by gravity.

$F = \mu N$ — $F$ = friction force
$\mu$ = coefficient of friction, 0 to 1.0
$N$ = normal force, or weight

The friction force is a fraction of the gravity force, N. With no gravity, then there would still be friction in the bearings and other mechanisms within the machine, and wind resistance forces, but here we will focus primarily on the downward gravity force and it's related friction.

If the rider and bicycle now encounter a hill, then additional pedaling effort (force) must be expended to maintain speed. This additional energy is required to gain altitude in a gravity field.

Returning now to level ground, if the road surface is removed from under the bicycle, then rider and bicycle fall and begin to acquire kinetic energy of motion -- $mv^2/2$. To keep from falling, the rider would need to provide additional energy (maybe by flapping arms) to balance the downward force of gravity to achieve a zero vertical velocity and maintain altitude.


Figure 1. Bicycle and rider floating in air.

If the rider wanted to remain at the same altitude, then an upward force, $F_{up}$ , would need to be generated somehow to balance the downward force, $F_g$ .

Energy is defined in physics as force x distance by the conventional definition of work energy. The distance is zero if no altitude change takes place, so the apparent work energy is zero, but try to convince the rider of that silly conclusion. Physics also defines power as force x velocity. Since the vertical velocity is zero to maintain altitude, then the apparent power is also zero. I propose to prove that to be not true.

Now consider compressing a coil spring between my two old hands. Work is done during compression and is equal to the force times the distance of compression, or the deflection. That work energy is stored in the strain of the spring. What happens after the spring is compressed and no further compression takes place? I do not want to relax the spring compression and let it fly off to smack my partner in the head, so I must continue to exert force to keep it compressed. Work energy was done on the spring to initially compress it, and now energy must flow to keep it compressed. The energy comes from the muscles in my arms (and the stored fat from my previous meal).

Now suppose that I place that spring upright on the ground and stand on it. It again compresses and the work energy of compression came from me as I raised my center of gravity to stand on it. This work energy is again equal to the product of force times distance. In this configuration of standing on the compressed spring with no change in elevation and no further deflection, I do not need to expend any further effort to keep it compressed. However, from the previous example, energy flow is still required to maintain compression. Where is it coming from? The only other point of contact is at the bottom of the spring with the ground. If I am not supplying effort to keep the spring compressed, then it must be coming from the other end. Through the influence of gravity force on my mass, the Earth is supplying the continuous energy flow required to keep the spring compressed. This sounds like a wild idea, but let's reason through it.

## 3. 1986 Essay

This is an edited version of the 1986 essay that was never published.

Abstract

A concept is presented that energy is required to support a mass in a gravity field. A mathematical formula is derived that describes this energy flow. The formula is tested with five examples of flying machines. It is suggested that other, more efficient, means of propulsion are possible.

Most everyone has had the experience of climbing uphill and the relative effort versus the rate of rise. Climbing up a steep hill requires more power than a gradual rise. As you walk uphill, you know that you have done some additional work above that required for walking on level ground. Your heart, muscles, and lungs are feeling the strain. If you ran up the same hill, then your same indicators tell you that you have worked even harder. Scientifically, you have done the same amount of work (as defined by the physics definition of work), but you have completed it in less time. Your power output was greater running up a hill versus just walking up. Specifically, a change in elevation requires work energy. The rate of elevation change determines the rate of work energy flow, or power. Physically, on a frictionless surface and with no viscous drag losses, zero energy is needed to continue in a straight line forever. Forever is a bad choice of words because nothing is forever, except death. This zero energy is also true in a gravity field if the object travels along an equipotential line. The Earth's surface is an approximate equipotential surface and it supports objects on it. In the absence of a supportive surface, objects will fall naturally to a lower energy level. Orbiting satellites are always falling. Combined with a lateral velocity, they circulate along an equipotential surface relative to the Earth, theoretically requiring no energy to continue along that path.

Now suppose that the supportive surface was removed below a stationary object and that we also desired for it to not fall. In that case, some effort will need to be provided to keep it "floating". The question is now - Why is it necessary to supply energy to prevent falling when none was required as the object rested on the surface? The answer is not obvious, but the surface and the mass of matter below the surface provided the required energy all along. The energy flow was not mechanical in the strict physics definition because there was no component of velocity in the direction of the force. There was, however, strain energy stored in the material below. When the object was initially placed on the surface, some energy was stored in compression of the material below. The weight of the object on the area of contact is a pressure that manifests itself as strain energy into a compressed material. This strain energy is what provides the upward force to support the object. When the supportive surface is removed, this energy flow must be continued to prevent the object from falling. It is not very large as we will see very soon, but it is not zero.

A real world example is a heavy mass resting on a table top. No energy is required from me as an observer to keep it from falling. Now imagine that the table is to be removed and my task is to keep the heavy weight from falling. I grasp two handles on the weight and prepare for the table legs to collapse. At precisely that moment, I begin to feel the muscle strain of work being done. Technically, no work is done because work equals force x distance, and the weight did not move so the distance is zero. Actually, work is being done and power is being expended. I intend to establish the minimum amount of power required to keep the weight levitated in a gravity field.

Now consider a slightly different situation. Suppose that I were to get under the table and push up. Also suppose that I increased my effort of pushing up at a slow rate. At first, the table would not move as I felt an increasing effort required of my muscles. The reaction force between the table legs and the floor would diminish as the force between my body and the floor increased. The table's reaction with the Earth becomes displaced in location from it's legs to my body. Now I am in the structural link supporting the table and it's weight, and I am expending a greater amount of power than just laying on my back. The additional energy is coming from stored body fat. At some level of effort depending on the weight, the table will start to rise. The difference between contact with Terra Firma and floatation of the table is the power number that I seek.

<u>The Equation</u>

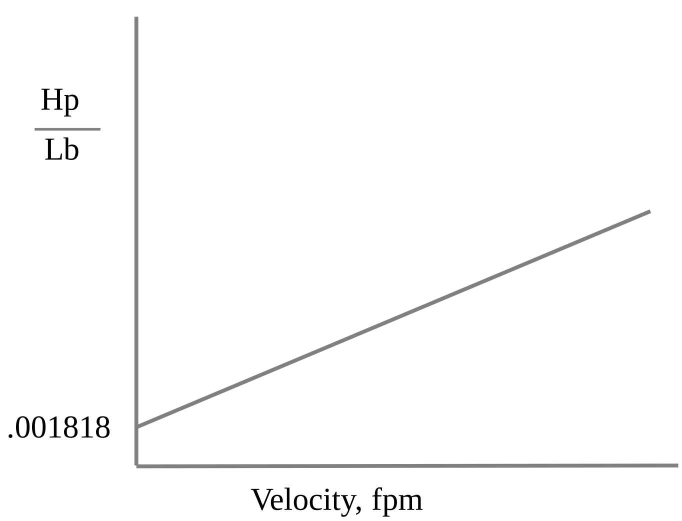
The mathematical form of an equation to describe this energy flow will consist of two power terms -- one to maintain floatation and the other to account for any rise in elevation. Objects of various mass will have different energy requirements, so the equation will be presented for a one pound mass or a one kilogram mass. The formulas are presented in both English engineering and SI units. A derivation will follow in the next section. The formulas assume a constant gravitational acceleration of 32.2 ft/sec$^2$ and 9.8 m/sec$^2$ respectively.

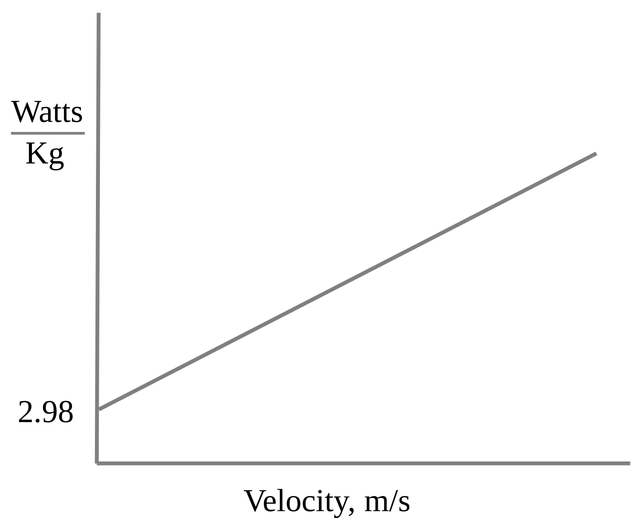
$$\frac{hp}{Lb_m} = .001818 + \frac{V}{33{,}000} \qquad \text{V in feet per minute}$$

$$\frac{watts}{kg} = 2.98 + 9.8\,V \qquad \text{V in meters per second}$$

Two observations can be made. The first term for floatation in a 32.2 ft/sec$^2$ (9.8 m/sec$^2$) gravitational field is a constant number per pound mass, or kilogram mass, .001818 and 2.98. The second term is dependent on the rate of vertical rise and is nothing new. If the vertical rise is zero for levitation, then the second term vanishes and we are left with a constant number describing the power input required to keep the one pound mass, or one kilogram mass, from falling.

The second observation is that this is the equation for a straight line. The abscissa is vertical velocity and the ordinate is the power flow per unit mass. The intercept is the constants .001818 or 2.98. The graphs are depicted below.




The straight lines cannot be continued to the left. In situations of negative vertical velocities (falling), the curve is no longer a straight line. When the velocity becomes negative, some energy is being transformed into kinetic energy of motion. There is then a different relationship between power flow and velocity. The straight line I have shown is an approximation with the assumption of a uniform gravity field, which is a valid assumption when the object does not rise or fall but only levitates. The constants of .001818 hp/$lb_m$ and 2.98 watts/kg can be interpreted as the power required to maintain floatation in a gravity field.

## The Derivation

The derivation will begin with the definition of power.

$$\text{Power} = \text{Force} \times \text{velocity}$$

The total power required will be the sum of two discrete components - one for floatation and the other to effect a change in elevation.

$$\text{Power} = \underset{\text{floatation}}{\underset{\vee}{FV}} + \underset{\text{rise}}{\underset{\vee}{FV}}$$

$$\text{Power} = maV + maV \qquad\qquad F = ma$$

The vertical velocity during floatation is zero, so we must consider the limiting case as the vertical velocity becomes smaller and smaller, that is, it approaches zero. It is then valid to take the derivative of the first term with respect to velocity.

$$\text{Power} = \frac{d(maV)}{dV} + maV$$

The mass is constant, and here we will assume that the acceleration is also constant and equal to the local value of the gravity acceleration, $g = 32.2\ ft/sec^2$.

$$\text{Power} = mg \cancelto{1}{\frac{dV}{dV}} + maV$$

For a one pound mass -

$$\frac{hp}{lb_m} = \frac{(32.2\ ft)}{(sec^2)} \frac{(ft)}{(sec)} \frac{(lb_f - sec^2)}{(32.2\ ft - lb_m)} \frac{(hp\ sec)}{(550\ ft - lb_f)} + \frac{(32.2\ ft)}{(sec^2)} \frac{(lb_f - sec^2)}{(32.2\ ft - lb_f)} \frac{(hp\ sec)}{(550\ ft - lb_m)} \frac{(V\ ft)}{(min)} \frac{(min)}{(60\ sec)}$$

$$= \frac{1}{550} + \frac{V}{(550)(60)} \qquad V \text{ in feet per minute}$$

$$\frac{hp}{lb_m} = .001818 + \frac{V}{33{,}000}$$

We shall call this the airborne formula. It can be generalized for other gravitational fields by substituting the appropriate acceleration constant for the local gravity. If there is a significant rise in altitude, then the gravity constant can become a variable.

Using a similar derivation for the formula in SI units, it becomes -

$$\frac{watts}{kg} = 2.98 + 9.8\,V \qquad V \text{ in meters per second}$$

Applications

What is the usefulness of knowing this equation? First, it gives us a relationship between the vertical velocity and power requirements, which is not new information. With this we can calculate the theoretical performance of any flying machine near the Earth's surface. We will do this in the next section. If we desire to rise very rapidly, then there will be huge demands of power from the prime mover. Second, and even more interesting in the first constant term is the absence of any altitude relationship to power. The altitude change is zero. The power requirement for floatation only depends on the weight. It gives us the lift capability of any power plant. In the case of zero vertical velocity, a one horsepower motor should be able to lift 550 pounds.

$$Lb_m = \frac{1\ hp}{.001818} = 550$$

This, of course, assumes 100% efficiency.

Third, and most important, this equation places no limitations on the process of propulsion. It only places a minimum energy requirement to lift a mass, or keep it from falling. It suggests that other, more efficient, propulsion mechanisms are possible.

The known propulsion mechanisms, traction and mass ejection, are applications of Newton's reaction principle. They have limitations. Traction is limited to a surface or medium to push against.

For mass ejection, propulsion stops when the supply of eject-able mass is gone. Modern technology places further limitations on these in the form of air breathing engines and short burn times of propellants. Imagine for a moment a mechanism that can generate a linear force with no reaction to it's environment and no mass flow across it's boundary. That may be hard to imagine for some because it does not reside in our memories, but that does not make it impossible. Imagine also that this force can be oriented in a vertical direction. If it could flow energy to it's operating mechanism and sustain this energy flow, then this equation predicts it's theoretical performance with no energy losses. It would be fun to entertain an example at this point.

Suppose that I wanted to lift 1,000 pounds to an altitude of 400 miles and I wanted to rise at 1,000 feet per minute. The 100% efficiency power requirement of the prime mover is --

$$hp = 1{,}000\ lb_m \left(.001818 + \frac{1{,}000\ fpm}{(33{,}000)}\right) = 32.1\ hp$$

The length of time that this engine would need to sustain this power level is - -

$$(400\ miles)\left(\frac{5280\ ft}{mile}\right)\left(\frac{min}{(1{,}000\ ft)}\right) = 2{,}112\ min \left(\frac{hr}{(60\ min)}\right) = 35.2\ hours$$

Now, if I had to get to this altitude in 20 minutes, then my rate of climb would be --

$$\frac{(400\ miles)}{(20\ minutes)}\left(\frac{5{,}280\ ft}{mile}\right) = 105{,}600\ fpm$$

The power required is then --

$$hp = (1{,}000\ lb_m)\left(.001818 + \frac{105{,}600\ fpm}{33{,}000}\right) = 3{,}202\ hp$$

So the rate of climb makes a big difference in the sustained power output that my prime mover must develop and maintain. This can be correlated to complexity, cost, and reliability. If I could tolerate waiting 35.2 hours, then I can get that 1,000 pounds up there for much less cost. There are plenty of engines around that develop 30 to 100 hp and they are lifting payloads of about 1,000 to 2,000 pounds in the form of light aircraft. Unfortunately, they are air breathing engines that choke at about 15,000 feet and they can only develop enough power at that altitude to maintain level flight. None is left over for additional climb.

Examples

To test the validity of the airborne equation, six examples of flying machines were investigated for conformance. These were a human powered aircraft, a solar powered aircraft, a light two-seat trainer, a commercial passenger transport, a military helicopter, and a hot air balloon. All of these vehicles have flown and performance data was available. They are listed in Table 1 with relevant performance numbers.

Table 1. Aircraft to test the airborne equation with data

| Description | Maximum engine output, hp | Gross weight at liftoff, $lb_m$ | Vertical climb capability at sea level, ft/min | References |
|---|---|---|---|---|
| Gossomar Condor | 0.45 | 215 | low | 1. |
| Solar Challenger | 3 | 353 | 200 | 2. |
| Cessna 152 | 108 | 1,670 | 715 | 3. |
| Boeing 727 | 19,200 | 130,000 | 3,000 | 4. |
| Sikorsky CH-53E | 13,140 | 56,000 | 2,500 | 5. |
| Hot Air Balloon | 1.5 | 684 | low | 6. |

The next task is to compare the actual flight performance of these six machines and compare to the theoretical minimum required power according to the airborne formula. With that comparison, the efficiency can also be calculated and tabulated. The resulting calculations are in Table 2.

Table 2. Performance comparisons

| Aircraft | Actual engine output | Minimum required | Efficiency = actual/minimum |
|---|---|---|---|
| Gossomar Condor | 0.45 | 0.39 | 87% |
| Solar Challenger | 3.0 | 2.78 | 92% |

| | | | |
|---|---|---|---|
| Cessna 152 | 108 | 39.2 | 36% |
| Boeing 727 | 19,200 | 12,054 | 63% |
| Sikorsky CH-53E | 13,140 | 4,344 | 33% |
| Hot Air Balloon | 1.5 | 1.24 | 83% |

The first observation from Table 2. is that the minimum theoretical power required is less than the actual maximum engine output. This is as it should be. One single observation to the contrary will invalidate the airborne formula. The equation appears to conform to these six examples of real vehicles. It remains to be seen if it stays valid for other examples. The calculated efficiencies are interesting. The heavy metal aircraft with large relative velocities are fuel pigs. The human powered Gossomar Condor, the Solar Challenger, and the hot air balloon are more efficient. The efficiency penalty of the fossil fueled powered aircraft are related to high speed motion through a fluid with corresponding viscous losses, and friction from high speed machinery on board.

The value of this equation is not in verifying past performance, but in predicting things yet to come. As can be seen in the examples, there are huge energy losses in reacting against a fluid. There are also tremendous demands on the power plant when faster climb rates are desired. The amount of power required to levitate a mass is really quite small. If the climb rates are kept reasonably low, then only a slightly larger engine is needed. We pay dearly when the machine must push against a fluid and large forward and vertical velocities are commanded.

## References

1. "Human Powered Flight", Mechanical Engineering, September 1984, vol. 106 no.9, pages 46 - 55. The horsepower output is reported as 0.25 hp. However, it was known that Bryan Allen (the pilot) was capable of producing significantly more power. The Standard Handbook For Mechanical Engineers reports the physiological limit for steady state useful power output of healthy males as .40 to .54

horsepower. Considering the superb physical condition of the pilot and the fact that he was worked almost to exhaustion for a 2 hour and 50 minute flight, I shall conservatively estimate the "engine's" output for this flight as 0.45 hp.

2. "Jane"s All the Worlds Aircraft", 1982 - 1983, page 411

3. "Jane's", 1983 - 1984, page 349

4. Ken Anderson, United Airlines Pilot. The gross weight at liftoff and vertical climb capability are typical values assuming standard temperature and pressure conditions. The maximum engine output is actually "thrust" horsepower calculated from the equation -

$$\text{hp (thrust)} = \frac{\text{(thrust) (forward velocity)}}{375}$$

For a 160 mph takeoff speed with typical loading conditions, the thrust horsepower is --

$$\text{hp (thrust)} = \frac{(45{,}000\ lb_f)\ (160\ mph)}{375} = 19{,}200$$

The engine efficiencies of accelerating a fluid flow have been deleted.

5. "Jane's", 1983 - 1984, page 486

6. Greg Pozzi, hot air balloon pilot of Rainbow Drifter, 220 pound envelope, 264 pound gondola, 200 pound pilot. For a one hour flight, 12.5 gallons of propane are consumed, which has a lower heating value of 19,944 BTU/$lb_m$, 0.1142 $lb_m/ft^3$, 0.1337 $ft^3$/gal, and calculates to 3,806 BTU for a 60 minute flight or approximately 1.5 hp.

## 4. Experimental Evidence

Shortly after relocating to New Mexico, two experiments were done to further explore the validity of the airborne equation. Both were supporting a weight with an electric machine, where the power flow can be easily measured with voltage and current measurements. The first was done in 1987 with a coil. The experimental setup is shown in Figure 2.

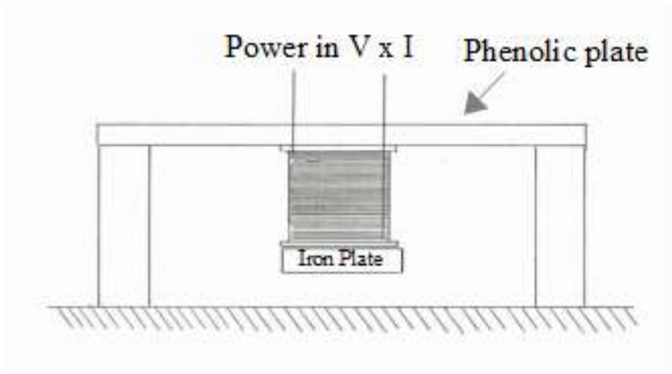



Figure 2. Electric coil energized to support an iron plate.

The coil had 9,000 turns with a resistance of 500 ohms. It was supported from a phenolic plate to be non-magnetic. Various iron metal plates  from 21 grams to 240 grams were used as the weights. The coil was energized with a precision DC power supply. The voltage and current were measured with separate multimeters. The mass was weighted with a fractional gram scale. The power to the coil was slowly increased until the iron object was captured and remained suspended. The test was repeated several times to check for repeatability, and the iron object was degaussed between each trial.

The average result from 28 trials was 1.3 watts/kg, which is less than the minimum expected. The conclusion was that the iron test piece was magnetized by the electromagnet coil. It retained this residual magnetism and the holding power was under measured. The iron plates, being magnetized, store energy. This supplemental conclusion presents an anomaly for physics which cannot explain how this energy is created, nor how it flows.

A second alternate test was conducted in 1991 with a DC motor supporting a weight from a string. The test setup is shown in Figure 3.

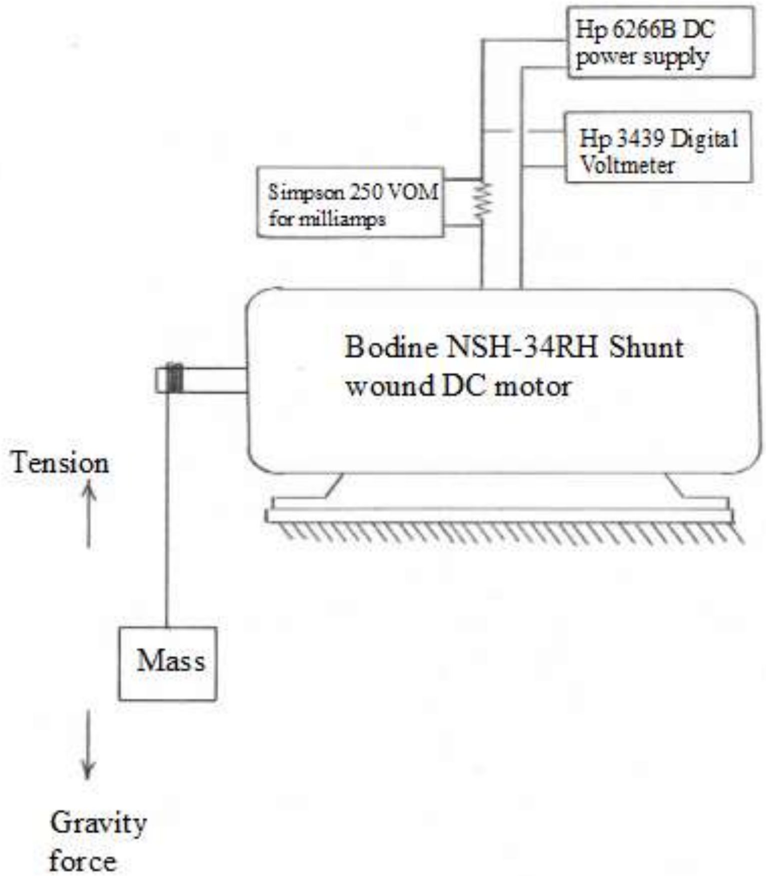



Figure 3. DC motor with a cord wrapped around its shaft supporting a weight from falling.

In preparation for this testing, the idle power to start rotating the motor shaft was measured several times to be 1.44 watts. This was done to determine the friction and hysteresis losses in the motor. That value was subtracted from the power measured to just barely start raising the weight. The weights ranged from 92 grams to 1,503 grams. Power to the motor in watts was calculated for both raising the weight, and for the reduced power when it started to fall. That is, up and down motion was tested. The 1.44 watts of idle power was subtracted for raising and added for falling. The resulting watts/kg were similar for each condition. The calculated power to raise and suspend each weight or let it fall was a low of 6 watts/kg to a high of 11 watts/kg. This compares favorably to the theorized minimum of 2.98 watts/kg.

## 5. Battery Lift

Paul McCready, an engineer who led the EV1 prototype design team for General Motors in the 1990's, declared that a lead acid battery has enough stored energy to lift itself to an altitude of 10 miles. That was an intriguing claim, and able to be calculated with standard physics formulas. The potential energy in a gravitational field is calculated as the product of mass x gravity x height, or PE = mgh. A standard automotive battery, size 31, SL 12 volt, has a one hour discharge rate of 64.5 Ahr and weights 72 $lb_m$ , or 32.6 kg. The stored energy in that battery is --

$$(12V)\ (64.5\ Ahr) = .774\ KWhr \times \frac{(3.6 \times 10^6\ J)}{KWhr} = 2.786 \times 10^6\ J$$

By re-arranging the potential energy formula to h = PE/mg --

$$h = \frac{(2.786 \times 10^6\ kg\ m^2)}{32.6\ kg\ \ sec^2} \left(\frac{sec^2}{9.8\ m}\right) = 8{,}270\ m \times \frac{(3.28\ ft)}{m} = 28{,}603\ ft$$

The height of 28,603 ft converts to 5.4 miles. That calculation is for a constant 32.2 $ft/sec^2$ gravity field.

When the gravity field is not constant, but decreases with height, then a slightly more complicated formula must be used that accounts for the diminishing force of gravity. The revised calculation results in that size 31 battery being capable of lifting itself 6,731 Km (3,959 miles) or a height approximately equal to the radius of the Earth.

Another interesting question for the size 31 automotive battery is; "How long can it float?" It will fall 9.8 meters in the first second and will need to raise itself that amount in the same time frame. It has storage of $2.786 \times 10^6$ J. or $2.786 \times 10^6$ watt - sec. It must deliver a minimum of 2.98 watts/kg, so with a mass of 32.6 kg, it must discharge 2.98 x 32.6 = 97.1 watts minimum every second. The 2,786,000 Joules will be gone in --

$$\frac{2{,}786{,}000\ watt - sec}{97.1\ watts} = 28{,}692\ seconds, or\ about\ 8\ hours.$$

## 6. Acceleration

According to Einstein's Theory of General Relativity, gravity is not a force, but an acceleration. It could be illuminating to approach this concept from an acceleration rather than a force and calculate the power needed to counter an acceleration of 9.8 $m/s^2$. The vertical force will be a constant 9.8 Newtons for a one kg mass while the vertical velocity is reduced to zero. By the definition of power being force x velocity, then the power will be zero when the velocity reduces to zero. That may seem to apply for a hot air balloon that is suspended in the atmosphere by buoyancy and not burning propane fuel. Something is holding that balloon up in the air, which is a pressure difference between the inside of the balloon envelope and the pressure outside. There is no upward velocity, but there is a balance of forces. The balloon is still bound to the 9.8 $m/s^2$ downward acceleration, but it is not falling and air pressure is keeping it floating.

Consider the situation where I held a 1 kg ball in my hand while on board the balloon. I would feel the weight as 9.8 Nt. Now, if I extended my arm beyond the gondola about one meter while still holding the 1 kg ball, there would still be a 9.8 Nt force on the ball, but the moment torque at my shoulder would become 9.8 Nt m. If I held it for one second, then the action would be 9.8 J s. If I could extend my arm further out or hold it longer, then there would be more action. That must somehow translate into more power from me. The objective of this analysis is to show somehow that the power does not disappear to zero but remains a constant 2.98 watts no matter how far extended.

An orbiting satellite is always falling, subject to the downward acceleration of the local gravity at that altitude. It has a sufficiently high tangential velocity to maintain altitude as it circles around on a curvilinear path. There is no outward acceleration or outward force keeping it up there. What if the tangential velocity were reduced to zero? The satellite would fall unless we could provide some force, or acceleration, or power flow to keep it up. The force we know – 9.8 Nt per kilogram. The acceleration we know - 9.8 $m/s^2$. What is the power? That is an open question that I am not able to answer at this time.

## 7. Implementation

There have been multiple, perhaps hundreds, of patents filed for “anti-gravity” machines. Since none of these have been commercially successful, the temptation is to blow it off as an impossible dream. Not so fast. Just because a working prototype has not been demonstrated does not, by any logic, disprove the idea. No one has ever seen such a device flying around, but the lack of experience is not a valid reason to reject the idea. Let’s examine this from a theoretical perspective and from engineering considerations.

By re-phrasing the situation as not shielding gravity, but producing a force that opposes gravity, then it is a different problem. Is it theoretically possible to generate a unidirectional force with no reaction to the environment and no mass flow ejection? That would seem to violate Newton’s 3$^{rd}$ law of action – reaction. That law must be qualified to apply only to rigid bodies in contact and at zero frequency. In a dynamic world, bodies are not rigid, but have elasticity. In addition, Newton’s laws, including the 2$^{nd}$ law, only apply strictly at zero frequency. The idea of a box with stored energy and some dynamic mechanism inside that produces a force in one direction only does not violate the conservation of energy principle.

Gravity appears to be stable, that is, a constant force, or acceleration, at a specific location in one direction only and not changing. Is it possible to produce a force that is in one direction from a mechanism that changes? The answer is yes, and there are examples all around us. The examples are pumps, fans, aircraft, fish, birds, and numerous flying insects. They react with the environment by pushing on it in the opposite direction. They all produce an oscillating motion internally that results in a push to the outside world. Suppose the push can be contained inside the box to push on it’s  outer envelope. Sounds like a crazy idea, but it would not violate the first law of thermodynamics – the conservation of energy principle. The energy input would be stored energy in the form of chemical or electrical energy, and the energy out would be power of motion.

There is a direct analogy in an electrical device called a diode. It receives oscillating energy in the form of an AC waveform and converts it to a unidirectional current output as DC. A mechanical diode would do the same thing, that is, receive as input an oscillating force (perhaps as a vibration) and produce a unidirectional force output.

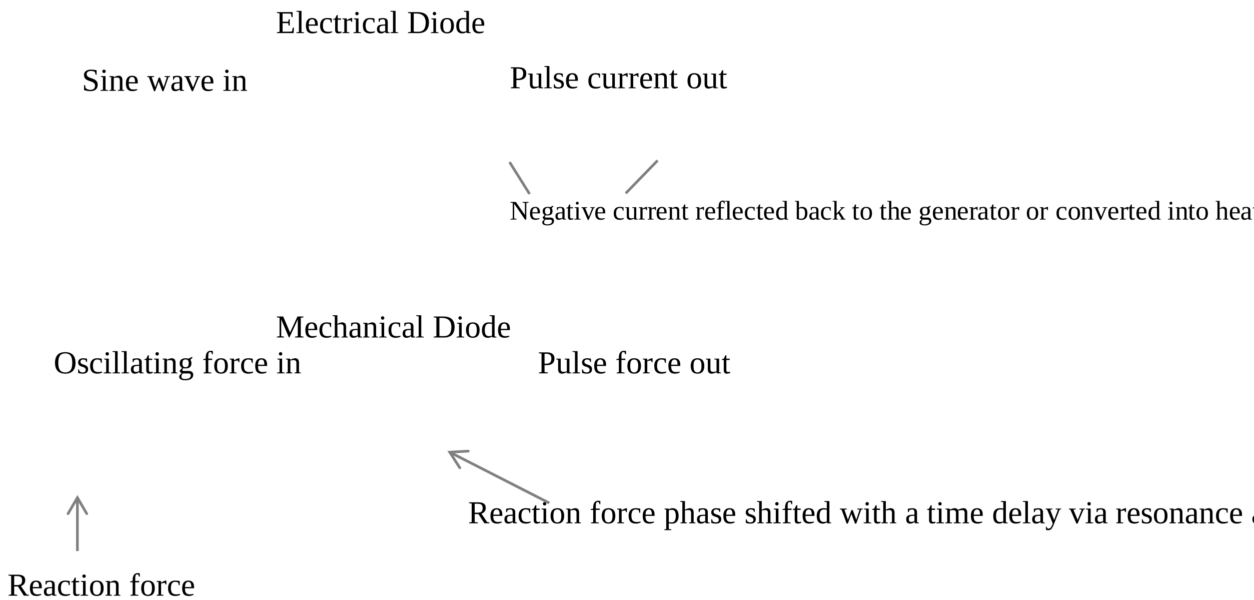



Figure 4. Electrical diode compared to a mechanical diode.

Professor Laithwaite had the idea of redirecting the reaction force via gyroscopic reaction. There are other ways to reduce the internal reaction forces with non-linear springs, absorb the reaction during one half of the cycle with fluid or frictional dampers, and phase shifting the reaction force during the negative half cycle with resonance.

All of these methods have been explored with limited success. The engineering task is to design a mechanical diode, which is a possibility. The bigger challenge will be to recover the energy on the way down with a regenerating device.

The airborne equation does not disallow such a device. It only describes the minimum amount of power to float and is an efficiency predictor.

current

displacement

linear

F

voltage

force

non-linear

F

Electrical Diode

Mechanical Diode

Figure 5. Comparison of electrical diode with a non-linear spring version for a mechanical diode.

## 8. Consequences

If Newton's 2nd and 3rd laws are always considered to be valid in a dynamic world, then this levitation concept is an impotent idea. Experimental engineers who do vibration measurements or dynamic testing are well aware that these laws do not apply in the real world. In fact, to retain Newton's laws, they have invented concepts of dynamic stiffness, dynamic mass, and mechanical impedance to still use the linear equations. Above 200 Hz frequency things are not rigid, with the consequence that the world can be considered to be made of gelatin stuff.

Gravity, that binds us here, can be conceived as a force or an acceleration, both of which are abstract concepts. They may not be real, but a manifestation of some sort of energy. Energy itself is an abstract concept. The one thing that is known to be real from first principles is motion. Motion is one thing that we can manipulate.

Objects being pulled down by force or acceleration, are compressing the material below. Compression creates strain energy in that material, which converts into heat. Heat is a form of energy. Large massive bodies are energy storage nodes for the universe. The matter of massive heavenly bodies are under compression and store energy as heat or gravitational energy. Gravity is a form of energy which we quantify as potential energy and it flows outward. It flow out to other masses that can detect it's  presence. Other masses can not only detect it's presence, but also it's direction and size. This is a form of communication. All communication is a form of energy transfer. These are metaphysical thoughts that lead to the eccentric conclusions that rocks have a primitive form of consciousness.

A more practical consequence of the airborne equation is that travel beyond the Earth can be done with less energy waste. We have rockets to propel us beyond the atmosphere. Those may be just our first trials; no need to stall with that technology.

## 9. Conclusions

I cannot predict what the outcome of this idea will be, nor if it will even be accepted or adopted. I can only open a door. Society will decide to enter that door or close it. Science is non-opinionated. True knowledge percolates over time.