Perpetual Motion Machines **O. Knill, Math21a**

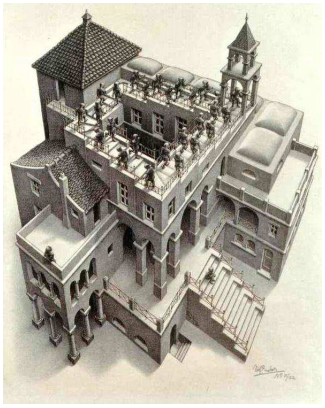
ABSTRACT. Is it possible to produce devices which produce energy? Such a machine is called a **perpetual motion machine** or with its latin name **perpetuum mobile**.

LINE INTEGRALS. If $F(x,y,z)$ is a vector field and $\gamma : t \mapsto r(t)$ is a curve, then $W = \int_a^b F(r(t)) \cdot r'(t)\, dt$ is called a **line integral** along the curve. The short-hand notation $\int_\gamma F \cdot ds$ is also used. If F is a force field, then W is **work**.

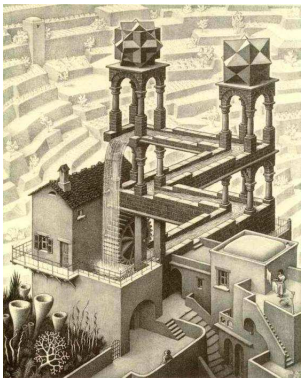
CLOSED CURVES. The fundamental theorem of line integrals assures that the line integral along a closed curve is zero if the vector field is a gradient field. The work done along a closed path is zero. In a physical context, this can be understood as energy conservation.

ENERGY CONSERVATION. All physical experiments so far confirm that static force fields in our universe are of the form $F = -\nabla U$, where U is a function called the **potential energy**. If a body moves in such a force field, its acceleration satisfies by Newton's laws $m\ddot{x} = F(x)$. The function $H(x(t)) = \dot{x}^2/2 + U(x)$ is conserved: $d/dt H(x(t)) = \ddot{x}\dot{x} + \nabla U(x)\dot{x} = (\ddot{x} + \nabla U(x))\dot{x} = 0$. The law of energy conservation is also called the **first law of thermodynamics**.

PERPETUUM MOBILES.



A machine which implements a force field which is not a gradient field is called a **perpetuum mobile** or **perpetual motion machine**. Mathematically, it allows that some closed loops have a non-vanishing line integral. By possibly changing the direction of the motion, the energy difference can always be turned to be positive.



The **first law of thermodynamics** forbids the existence of such a machine. It is informative to study some of the ideas people have come up in history (and today!) and to see why they don't work. Also the drawings of Escher suggest - using graphical tricks - that perpetual motion should exist.

WHY ARE THERE NO PERPETUUM MOBILES?

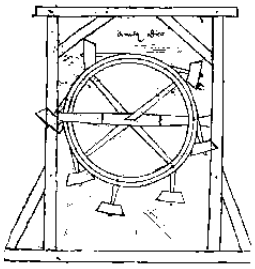
As an "explanation" one could invoke the **antropic principle**:

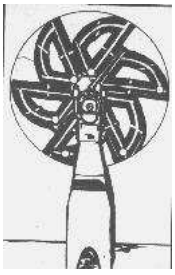
In a universe with a such a field, an arbitrary amount of energy could be produced and nothing would prevent this to happen spontaneously. This energy production could lead to energy fluctuations, arbitrary large ones. These energy bursts would destroy an observer.

This argument is **not a proof** for the nonexistence of perpetual motion machine but it provides a plausible reason why the **first law of thermodynamics** should hold at least on the macroscopic scale we can observe. A world without this law would likely be too hostile for life to exist.

WHEEL SUGGESTIONS (1235).

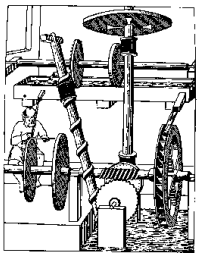
The oldest known attempt for a perpetuum motion machine is from the year 1245. There are seven hammers attached to a wheel. On the top, the weights flip on the other side in order that on the left hand side, there will always be 4 weights and on the right hand side three. A similar idea was designed by Leonardo da Vinci around 1500. You might think that such inventions from the past. The web is however full with suggestions See for example http://www.free-energy.co.uk.





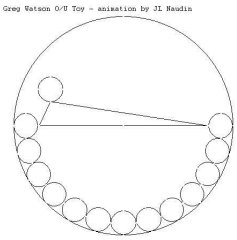
WATER MACHINE (1620).

Water flowing down turns an pump which transports the water back up. There are many variants of this idea: a electric motor which turns a generator whose electricity is used to power the motor. In all of these ideas, there is a twist like some kind of gear or change of voltage which confuses a naive observer.



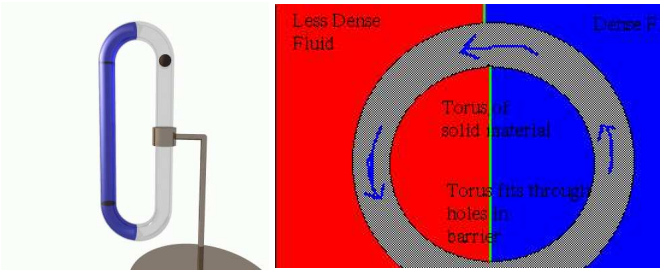
BALL MACHINE (1997).

The energy needed to lift the balls up is claimed to be smaller than the energy gained from pushing the other balls. The website http://jnaudin.free.fr/html/rsmot.htm on which the idea was posted says: "This device is NOT TESTED today"

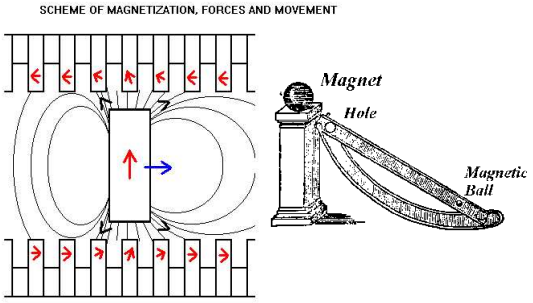


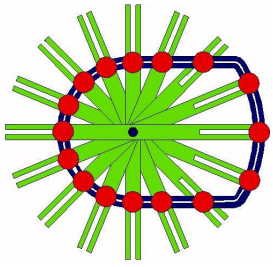
U TUBE SUGGESTION.

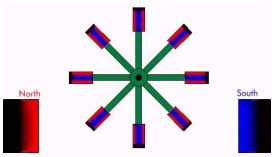
The first suggestion for a perpetual motion machine is a O shaped tube which is filled on one side with water. There are two valves each of which when closed prevent the water from falling. Opening and closing the walls does not use energy. A wooden ball falls in the air and is dragged up inside the water.

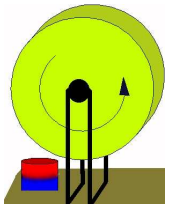


MAGNETIC MACHINES on *http* : *//www.geocities.com/k_pullo/PM3.htmm*, there is an attempt for a perpetual motion machine based on magnets. The author seems serious in claiming that the magnetic field from the moving magnet will change the magnetic field from the stationary magnets in such a way that the magnet will move.









A RECENT INVENTION.

The web is full of suggestions. An example of a perpetuum mobile which had actually been built is a machine by Reidar Finsrud http://www.theverylastpageoftheinternet.com/magneticDev/finsrud/finsrud.htm