ROMANIAN CONTRIBUTIONS IN AERONAUTICS

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A short history of the flight

From the earliest days, humans have dreamed of flying and have attempted to achieve it. The dream of flight was inspired by the observation of the birds even from the early times and was illustrated in myths, fiction (fantasy, science fiction and comic book characters) and art. Greek, Roman or Indian mythology have examples of gods who were gifted with flight. Daedalus and Icarus flew through the air, and Icarus died when he flew too close to the sun.

Daedalus and Icarus (Greek)

Pushpaka Vimana of the Ramayana (Indian)

Religions relate stories of chariots that fly through the air and winged angels that join humans with the heavens. Flying creatures that were half human and half beast appear in legends. Birds and fantastic winged creatures pulled boats and other vehicles through the air. Let's see some relevant examples:

From the top left corner: Angel, Pegasus, Dragons, Superman, Santa Claus, Dumbo.

My talk is about progress in science, and more specific, about progresses in human fight against gravity. An illustration in art of the idea of what it means the progress in flight is given in the picture below, painted at the end of the 19th Century:

The human dream of flight: Utopian flying machines from the 18th Century.

The image and the title of this art work express, maybe better than other words, the idea of progress in flight, especially in modern and present history: things that seemed to be pure utopia a century before are reached in present and, no doubt about it, will become obsolete in a few decades! Yes, things happen very fast in aeronautics, but never forget that often the steps further were performed by some outstanding and, why not, heroic scientists who were ready to pay even with their life in order to transform the human dream of flight into reality!

Here is a short list of some of them, together with their accomplishments:

Inventor	Accomplishment	Year
Zhuge Liang	Kongming lantern, first hot air balloon	2nd or 3rd century
Yuan Huangtou	Manned kite, first successful manned flight	559[1]
'Abbas Ibn Firnas	First parachute flight	852
'Abbas Ibn Firnas	First hang glider, single flight of manned glider-wings	875
Lagari Hasan Çelebi	First rocket flight	1633
Montgolfier brothers	Modern hot air balloon	1783
Henri Giffard	Dirigible, hydrogen balloon powered by steam engine	1852
Sir George Cayley	Cayley Glider, flight of manned glider	1853
Félix du Temple de la Croix	Monoplane (1874) First powered manned flight	1857 - 1877
John J. Montgomery	Montgomery Monoplane and Tandem-Wing Gliders	1883 - 1911
Otto Lilienthal	Derwitzer Glider, Normal soaring apparatus and others, many flights	1891 - 1896
Count Ferdinand von Zeppelin	Zeppelin airship LZ 1	1900
Wright brothers	Wright Flyers I - III, worlds 1st controlled flights	1903 - 1905
Louis Blériot and Gabriel Voisin	Blériot-Voison floatplane glider, biplane	1905
Traian Vuia	Vuia I, Vuia II First unofficial autonomous controlled take-off and flight.	1906 - 1907
Jacob Ellehammer	Ellehammer monoplane	1906 - 1907
Alberto Santos-Dumont	14-bis, Demoiselle First official European autonomous controlled take-off and flight.	1906 - 1907
Aurel Vlaicu	Vlaicu 1909, Vlaicu I, Vlaicu II, Vlaicu III	1909-1910
Henri Fabre	Le Canard, First seaplane.	1910
Henri Coanda	Coanda 1910 Biplane First jet engine flight.	1910

http://en.wikipedia.org/wiki/List_of_early_flying_machines

Aviation history deals with the development of mechanical flight, from the earliest attempts in kite-powered and gliding flight, to the demonstration of sustained, controlled and powered heavier-than-air flight, and beyond.

Humanity's desire to fly possibly first found expression in China, where human flight tied to kites is recorded (as a punishment) from the sixth century AD. Subsequently, the first hang glider was demonstrated by Abbas Ibn Firnas in Andalusia in the 9th century AD. Leonardo da Vinci's (15th century AD) dream of flight found expression in several designs, but he did not attempt to demonstrate flight. It was in post-industrial Europe from the late 18th century that serious attempts at flight took place, with progression from lighter-than-air (hot-air balloons, 1783), unpowered heavier-than-air (Otto Lilienthal, 1891), and finally, powered, sustained, flight (Wright Brothers, 1903). Since then, aircraft designers have struggled to make their craft go faster, further, fly higher, and be controlled more easily. The dream was fulfilled in 1969, when Neil Armstrong and Buzz Aldrin (Apollo 11 mission) set foot on the Moon for the first time.

The problem of “priority” is a major source of controversy for early flying machines. Even the definition of "flight" is not agreed upon. There are kites, parachutes, lighter than air craft (balloons/airships), gliders and powered aircraft, which all have some ability to fly. Some inventions focused only on staying in the air, and had little or no ability to steer the craft, which makes them useless for practical flight. On the other hand, rather than specific, technical achievements, some claims to flight are more general. With the myriad of different challenges surrounding flight, succeeding in some is still an accomplishment. In truth, the more successful inventors built on the works of those who preceded them; those that did the earlier work deserve some credit. Science is a chain of corrected mistakes!

The physics of flight

Flight can be defined as simply not falling when in the air, or, more precisely, as the process by which an object achieves sustained movement either through the air by aerodynamically generating lift or aerostatically using buoyancy, or movement beyond earth's atmosphere, in the case of spaceflight.

The most successful groups of living things that fly are insects, birds, and bats. Each of these groups' wings evolved separately from different structures. The human beings are not “gifted” with natural means for flying, so they had to use the force of the brain in order to fight against gravity. We can speak about *mechanical flight,* which is the use of a machine, called an aircraft, to fly. These machines include kites, helicopters, airships, balloons, and spacecrafts.

The first experimenter who actually analyzed the various forces that contributed to flight was the Englishman George Cayley at the end of the eighteenth century. Cayley identified and defined the forces of flight, the principles of mechanical flight and stated that, to fly, it was necessary for surfaces to be able to support a weight by applying "power to the resistance of air." In other words, the force that moved an object in a forward direction had to be greater than the opposite force (resistance or drag) that the air exerted on an object.

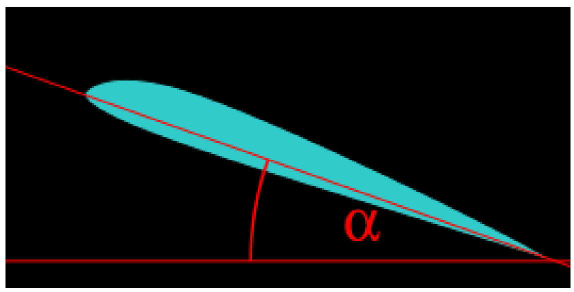
The most important forces for flight are:

- **Weight**: (created by gravity)
- **Buoyancy**: for lighter than air flight
- **Drag**: Created by airflow
- **Propulsive thrust**: (except in gliders)
- **Lift**: Created by wings

In fluid dynamics, **drag** (sometimes called **resistance**) is the force that resists the movement of a solid object through a fluid (a liquid or gas). Drag is made up of friction forces, which act in a direction parallel to the object's surface (primarily along its sides, as friction forces at the front and back cancel themselves out), plus pressure forces, which act in a direction perpendicular to the object's surface. It therefore acts to oppose the motion of the object, and in a powered vehicle it is overcome by **thrust**.

The **lift force** or simply **lift** is a mechanical force generated by solid objects with certain shapes as they move through a fluid. The object may be moving through a stationary fluid, or the fluid may be flowing past a stationary object - the effect is the same in both cases. While many types of objects can generate lift, the most common and familiar object in this category is the airfoil, a relatively flat object of which the common airplane wing is an example. Technically, lift is the sum of all the fluid dynamic forces on a body perpendicular to the direction of the external flow approaching that body. Sometimes the term **dynamic lift** or **dynamic lifting force** is used for the perpendicular force resulting from motion of the body in the fluid, as in an aerodyne, in contrast to the static lifting force resulting from buoyancy, as in an aerostat. Lift is commonly associated with the wing of an aircraft. However there are many other examples of lift such as propellers on both aircraft and boats, rotors on helicopters, sails and keels on sailboats, hydrofoils, wings on auto racing cars, and wind turbines. While the common meaning of the term "lift" suggests an upward action, the lift force is not necessarily directed up with respect to gravity.

The lift generated by an airfoil depends on such factors as the speed of the airflow, the density of the air, the total area of the airfoil, and the *angle of attack.* The angle of attack is the angle at which the airfoil meets the oncoming airflow (or vice versa).



The *angle of attack*

A symmetric airfoil must have a positive angle of attack to generate positive lift. At a zero angle of attack, no lift is generated. At a negative angle of attack, negative lift is generated. A cambered airfoil may produce positive lift at zero, or even small negative angles of attack.

The basic concept of lift is simple. However, the details of how the relative movement of air and airfoil interact to produce the turning action that generates lift are complex. Lift is created as the fluid flow is deflected by an airfoil or other body. The force created by this acceleration of the fluid creates an equal and opposite force according to Newton's third law of motion. Air deflected downward by an aircraft wing, or helicopter rotor, generating lift is known as downwash.

The conventional or standard explanation of aerodynamic lift is that the higher streaming velocity at the upper side of the airfoil causes of the lower pressure, as a consequence of Bernoulli's law:

$$\frac{v^2}{2} + gh + \frac{p}{\rho} = \text{constant}$$

which states that in fluid flow, an increase in velocity occurs simultaneously with a decrease in pressure. So, there are two techniques for increasing the lift on an airfoil. One is to decrease the pressure on the side of the airfoil normal to the direction of the desired lift and the other is to increase the pressure on the other side (the latter is the primary cause of the lift of a paper airplane). In order to generate lift one must create a pressure differential between the top and bottom of the airfoil. This explanation ignores the effects of viscosity, which can be important in the boundary layer and to predict drag, though it has only a small effect on lift calculations. More than this, never forget that a higher streaming velocity is the effect of a lower pressure and never its cause. The cause of the aerodynamic lifting force is the downward acceleration of air by the airfoil - which depends on the angle of attack and its velocity.

Another effect which accounts for part of the lift generated by an airfoil is the Coandă effect. The Coandă effect is the name given to the tendency of an airflow, under some conditions, to deflect toward a surface that curves away from the flow direction. This effect is caused by the decreased pressure on the curved surface where it curves away from the flow. The decrease in pressure above the airfoil is caused by the interaction of the flow, at the microscopic level, with the curved surface. The effect is caused by a decrease of the pressure on the top of the wing as air particles are blown away from the surface (fewer particles, less pressure due to thermal molecular motion).

If one holds the back of a spoon in the edge of a stream of water running freely out of a tap (faucet), the stream of water will deflect from the vertical in order to run over the back of the spoon. This is the Coandă effect in action:

The Coandă effect has been used successfully in the design of the wings in Formula One race cars to pressurize the back of the car and partially offset drag.

Romanian contributions in aeronautics
Traian Vuia (August 17, 1872 - September 3, 1950)

Traian Vuia was a Romanian inventor, who designed and built the first self-propelling heavier-than-air aircraft. This item is disputed, however, given that in the United States, the Wright brothers had already successfully flown the Wright Flyer on December 17, 1903.

"I don't work for my glory, but for the glory of the human genius"

Traian Vuia was born on 7 August 1872, in the village Surducul Mic (now Traian Vuia) of Banat, a Romanian region belonging then to the Austro-Hungarian Empire.

After attending the primary school in his village, he went for the high school to Lugoj, graduating in 1892. Vuia was very fond of mechanics and especially of the aviation one. When he was ten years old he attended the firsts aeronautical demonstrations and he developed a real passion for flight and kits.

After graduating the Polytechnic University of Budapest, School of Mechanics where he got his engineering diploma, he returned to Lugoj. He continued studying the problem of human flight and he designed his first flying machine which he called *the airplane-car* and tried to build this machine. Due to financial constraints, he decided to go to Paris, in July, 1902, where he thought he will find someone interested in financing his project. He went to Victor Tatin, a known theoretician and experimentator who built an aeromodel in 1879. Tatin was immediately interested in Vuia's project, but also tried to persuade him that there was nothing he could do, since Vuia's project did not have a suitable engine and it would not be stable enough. But Vuia continued to trust in his project, so he sent to the Académie des Sciences of Paris on February 16, 1903, a paper on a monoplane flight which he called *"airplane-automobile"* presenting the possibility of flying with a heavier-than-air mechanical machine and his procedure for taking off, but the project was rejected for being utopian, adding the comments:

The problem of flight with a machine which weights more than air can not be solved and it is only a dream.

In spite of all these refusals, Vuia did not give up and he submitted the project to the *"Office national de la propriété industrielle"* and obtained the patent *No.* 332106 for his flying machine, published on October 16, 1903.

Vuia begun to build the flying machine in the winter of 1902-1903. He encountered many difficulties, the most important being of financial nature, but he succeeded in overcoming them when he received financial support of some friends from Lugoj. In the autumn of 1904, he began building the engine, also his own invention. In 1904, he got a patent for his invention in the United Kingdom.

A postcard with Vuia and his airplane (weight 250 kg, surface 14 m^2 and a 20 PH engine)

This aircraft was called "Traian Vuia 1" or “The bat”. It was a monoplane with a high-wing, consisted of a triangular tubular steel frame *set on four tire wheels (for the first time, at least* *in Europe)*, pivoting wings and an engine driven with a single tractor propeller. On March 18, 1906, in Montesson, near Paris, "Vuia I" was set to take off. He accelerated and after about 50 meters, the plane left the soil and flew at about one meter in height for about 12 meters then the propeller stopped and the aircraft landed.

Many newspapers in France, the US, and the United Kingdom wrote about the first man to fly with a heavier-than-air machine with their own take off systems, propulsion units and landing gear. The thing that has been emphasized ever since about Vuia's achievement, is that his machine was able to take off on a flat surface "only by on-board means", without any "outside assistance", be it an incline, rails, a catapult, etc. However there was, and is, much disagreement over precise definition of the "first" airplane.

Between 1918 and 1921 he built two experimental helicopters on the Juvissy and Issy-les-Moulineaux aerodromes, contributing to the development of vertical take-off.

Another great invention of him was a steam generator (1925) with internal combustion that could generate steam with very high pressure of more than 100 atmospheres (10 MPa), that is still used today in all thermal power stations.

On May 27, 1946, he was named Member of Honor of the Romanian Academy.

He lived in France until 1950, when he came back to Romania. Very ill, he died on September 3, 1950.

He is buried at the Bellu cemetery, in Bucharest.

Today Timişoara International Airport (TSR), Romania's second largest airport, carries his name.

Aurel Vlaicu (November 19, 1882 – September 13, 1913)

Aurel Vlaicu was a Romanian engineer, inventor, airplane constructor and early pilot.

"The human spirit didn't remain enchained to the ground,
while science opened the gates of the sky"

Aurel Vlaicu was born in Binținți (now Aurel Vlaicu), near Orăştie, Transylvania, which was part of Austria-Hungary at the time. He attended Calvinist High School in Orăştie (renamed "Liceul Aurel Vlaicu" in his honour in 1919) and took his Baccalaureate in Sibiu in 1902. He continued his studies at Technical University of Budapest and Ludwig-Maximilians-Universität München in Germany, earning his engineer's diploma in 1908.

After working at Opel car factory in Rüsselsheim, he returned to Binținți and built a glider he flew in the summer of 1909. Later that year, he moved to Bucharest, in the Kingdom of Romania, where he began the construction of *Vlaicu I* airplane.

Vlaicu and his airplane (weight 200 kg and a 50 hp engine)

In 1909 he went to Paris, trying to find an engine for his aircraft and he met Traian Vuia who advised him regarding the engine. The aircraft was a canard aerodynamic type, with the stabilizer in front and a variable camber wing. The weight of the aircraft was 200 kg and was powered by a 50 hp Gnome engine, spinning two counter rotating propellers. On June 17, 1910, Vlaicu took off for the first time with his aircraft from Cotroceni field, near Bucharest, flying about 40 m at 3 - 4 m altitude. On July 23, 1910, Vlaicu, took off again, but this time he flew about 400 m, at 4 m altitude. At third try, on August 10, 1910, he climbed at an altitude of 40 - 50 m and flew about 4 km. The airplane had a good stability being in the same time very maneuverable and very well built.

In 1910 he was invited by the Ministry of Defense to participate to the military exercise, his mission being to carry a message from Slatina to Piatra Olt, which put Romania on second place in use of airplane for military purpose, after France.

In 1910 he gets the patent RO 2258 for "Flying machine with arrow shape body". Also, in the fall of 1910, supported by Minister of Education - Spiru Haret, he starts the design of his second aircraft - "Vlaicu-II", the first *national aircraft*. With this aircraft built in 1911, a “bird made of sticks and canvas”, he flew in numerous occasions, establishing different records - 100 m altitude, 90 km/h airspeed, aerobatics. For his achievements and excellence he was awarded the "Gheorghe Lascar" prize by the Romanian Academy. During his career, he had built one glider and three airplanes and also he designed a dirigible balloon, that was never built due to lack of funding. Also he introduced the wing with variable profile, engine cowling and the tricycle landing gear.

In 1912, flying together with big names of that time, he wins two memorable prizes at Aspern, Austria, the first place for accuracy in launch of a projectile to a ground target from an altitude of 300 m and second place, after the well known Roland Garros, for precision landing.

Between 1912 - 1913 he started to work to Vlaicu-III, the first aircraft in the world to have an all metal fuselage and a cowling around the engine to reduce drag, later known as NACA cowling.

In 1913 he found out that a foreign aviator wants to try a first flight over Carpathian Mountains so he hurried to be the first to achieve this record, flying with his old airplane Vlaicu-II. Unfortunately, during the flight the aircraft crashed at Banesti village, near Câmpina, on September 13, 1913, killing its great pilot, Aurel Vlaicu.

He is buried at the Bellu cemetery, in Bucharest.

In 1916, during the German occupation of Bucharest, *Vlaicu III* was seized and shipped to Germany. The airplane was last seen in a 1942 aviation exhibition in Berlin.

Vlaicu was posthumously elected to the Romanian Academy in 1948.

Henri Marie Coandă (June 7, 1886 – November 25, 1972)

Henri Marie Coandă was a Romanian inventor, aerodynamics pioneer and the builder of world's first jet powered aircraft, the Coandă-1910.

> "These airplanes we have today are no more than a perfection of a child's toy made of paper. In my opinion, we should search for a completely different flying machine, based on other flying principles. I imagine a future aircraft, which will take off vertically, fly as usual, and land vertically. This flying machine should have no moving parts. This idea came from the huge power of cyclones."

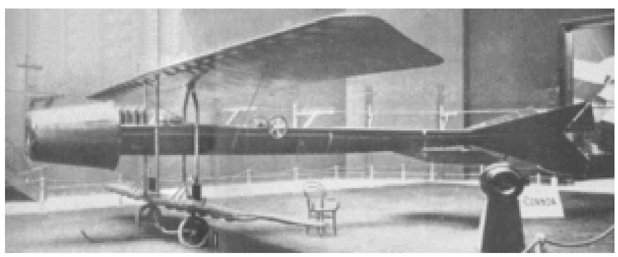
Born in Bucharest, Coandă was the second child of a large family. His father was General Constantin Coandă, a mathematics professor at the National School of Power and Roads. His mother, Aida Danet, was the daughter of French physician Gustave Danet, and was born in Brittany. He was later to recall that even as a child he was fascinated by the miracle of wind.

Coandă studied at the *Petrache Poenaru* Communal School in Bucharest, then (1896) at the Liceu *Sf. Sava* (Saint Sava National College). After three years, his father, who desired a military career for him, had him transfer to the Military High school in Iaşi. He graduated from that institution in 1903 with the rank of sergeant major, and he continued his studies at the School of Artillery, Military, and Naval Engineering in Bucharest. Sent with an artillery regiment to Germany (1904), he enrolled in the Technische Hochschule in Charlottenburg, Berlin.

Coandă graduated as an artillery officer, but he was more interested in the technical problems of flight. In 1905, he built a missile-airplane for the Romanian Army. He continued his studies (1907-1908) at the Montefiore Institute in Liège, Belgium, where he met Gianni Caproni. In 1908 Coandă returned to Romania to serve as an active officer in the Second Artillery Regiment. However, his inventor's spirit did not comport well with military discipline. He solicited and obtained permission to leave the army, after which he took advantage of his renewed freedom to take a long automobile trip to Isfahan, Teheran, and Tibet. Upon his return in 1909, he travelled to Paris, where he enrolled in the newly founded École Nationale Superieure d'Ingenieurs en Construction Aéronautique (now the École Nationale Supérieure de l'Aéronautique et de l'Espace, also known as SUPAERO). One year later (1910) he graduated at the head of the first class of aeronautical engineers.

With the support of the engineer Gustave Eiffel and the mathematician, politician, and aeronautical pioneer Paul Painlevé, he began experimenting the aerodynamic techniques: one of this experiments was mounting a device on a train running at 90 km/h so he could analyze the aerodynamic behavior. Another experiment used a wind tunnel with smoke and an aerodynamical balance to profile wings to be used in designing aircraft. This later led to the discovery of the aerodynamic effect now known as the Coandă effect.

In 1910, using the workshop of Gianni Caproni, he designed, built and piloted the first 'thermojet' powered aircraft, known as the Coandă-1910, which he demonstrated publicly at the second International Aeronautic Salon in Paris. The aircraft used a 4-cylinder piston engine to power a compressor, which fed to two burners for thrust, instead of using a propeller.



Coandă-1910 jet-plane

At the airport of Issy-les-Moulineaux near Paris, Coandă lost control of the jet plane, which went off of the runway and caught fire. Fortunately, he escaped with just a good scare and some minor injuries to his face and hands. Short time after, Coandă abandoned his experiments due to a lack of interest and support on the part of the public and of scientific and engineering institutions.

Between 1911 and 1914, he worked as technical director of Bristol Aeroplane Company in the United Kingdom, where he designed several airplanes known as Bristol-Coandă airplanes.

In 1934 he was granted a French patent related to the *Coandă Effect*. In 1935, he used the same principle as the basis for a hovercraft called "Aerodina Lenticulara", which was very similar in shape to the flying saucers later developed by Avro Canada before being bought by the United States Air Force and becoming a classified project.

In 1969, during the first years of the Ceaușescu era, he returned to spend his last days in his native Romania. He served as director of the Institute for Scientific and Technical Creation (INCREST) and in 1971 reorganized, along with professor Elie Carafoli, the Department of Aeronautical Engineering of the Polytechnic University of Bucharest, spinning it off from the Department of Mechanical Engineering.

Coandă died in Bucharest on November 25, 1972, at the age of 86.

Bucharest's Henri Coandă International Airport is named after him.

Hermann Julius Oberth (June 25, 1894 – December 28, 1989)

Hermann Julius Oberth was along with the Russian Konstantin Tsiolkovsky and the American Robert Goddard, one of the founding fathers of rocketry and astronautics. The three were never active collaborators; instead, their parallel achievements occurred independently to each other.

Hermann Julius Oberth, was born on June 25, 1894 in the Transylvanian town of Sibiu (Hermannstadt). Oberth's interest in rocketry was sparked at the age of 11. His mother gave him a copy of Jules Verne's *From The Earth To The Moon*, a book which he later recalled he read "at least five or six times and, finally, knew by heart". The young Oberth discovered that many of Verne's calculations were not simply fiction, and that the very notion of interplanetary travel was not as fantastic as had been assumed by the scientific community.

By the age of 14 Oberth had already envisioned a "recoil rocket" that could propel itself through space by expelling exhaust gases (from a liquid fuel) from its base. He arrived independently at the concept of the multistage rocket, but lacked, at the time, of the resources to pursue his ideas on any but a theoretical level.

In 1912 Hermann Oberth enrolled in the University of Munich to study medicine. His scholarly pursuits, however, were interrupted by the First World War. In an indirect way, Hermann Oberth's participation in the war, mostly with the medical unit, was, in some ways, fortunate for the future of rocketry. Hermann Oberth stated it best when he wrote that one of the most important things he learned in his years as an enlisted medic, was that he "did not want to be a doctor". When the war was over, Oberth returned to the University of Munich, but this time to study physics with several of the most notable scientists of the time.

In 1922 Oberth's doctoral thesis on rocketry was rejected. He later described his reaction: "I refrained from writing another one, thinking to myself: Never mind, I will prove that I am able to become a greater scientist than some of you, even without the title of doctor". He continued: "In the United States, I am often addressed as a doctor. I should like to point out, however, that I am not such and shall never think of becoming one". And on education he had this to say: "Our educational system is like an automobile which has strong rear lights, brightly illuminating the past. But looking forward things are barely discernible".

Hermann Oberth was finally awarded with the title of doctor in physics with the same paper, by professor Augustin Maior, at Babeş-Bolyai University of Cluj-Napoca (Romania), on May 23, 1923. In the same year he published the 92 page *Die Rakete zu den Planetenraumen* (*The Rocket into Planetary Space*). This was followed by a longer version (429 pages) in 1929, which was internationally celebrated as a work of tremendous scientific importance.

That same year, he lost the sight in his left eye in an experiment while working as a technical advisor to German director Fritz Lang on his film, "Girl in the Moon".

In autumn 1929, Oberth launched his first liquid fuel rocket, named *Kegeldüse*. He was helped in this experiment by his students at the Technical University of Berlin, one of whom was Wernher von Braun, who would later head the wartime project to develop the rocket officially called the *A4*, but far better known today as the V-2 rocket. They worked together again after the war, in the United States at the U.S. Army's Ballistic Missile Agency in Huntsville, Alabama.

In 1958 Professor Oberth returned to Germany but in 1960, he is back in the United States again, to work for Convair as a technical consultant on the Atlas rocket. He retired in 1962 at the age of 68. In July 1969, he returned to the USA to witness the launch of the Saturn V rocket that carried the Apollo 11 crew on the first landing mission to the Moon.

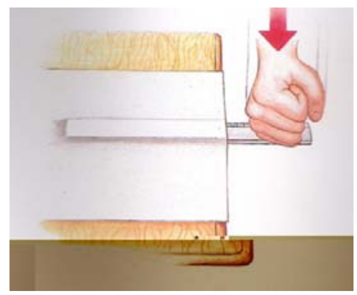
Hermann Julius Oberth died in a Nurenberg hospital in West Germany on December 29, 1989 at the age of 95.

Oberth is memorialized by the Hermann Oberth Space Travel Museum in Feucht, and by the Hermann Oberth Society, which brings together scientists, researchers and astronauts from East and West in order to carry on his work in rocketry and space exploration.

Also, a crater on the Moon was named after him. The SF serie *Star Trek III: The Search for Spock* featured an *Oberth*-class starship in his honor. In Hideo Kojima's space adventure game, *Policenauts*, there is an extravehicular mobility suit called *the Oberth*.

4. Some experiments introducing flight physics concepts

4.1 The “resistance” of air

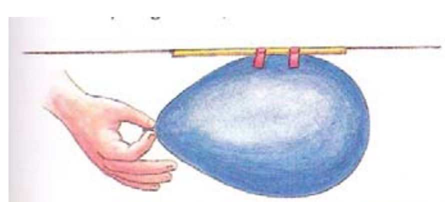


We need:

– a wooden rule
– a sheet of paper

When we hit the free part of the wooden rule, the sheet of paper “opposes” the upward motion of the rule. This is due to the air pressure acting on the large surface of the sheet of paper.

The reaction balloon (the air propulsion)



We need:

– a wire
– scllotape
– a balloon
– a straw

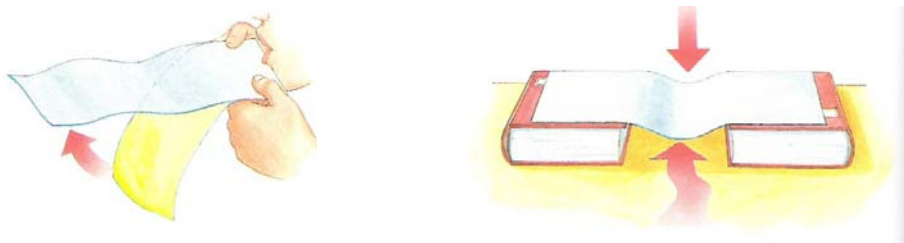
We put the straw on the wire and fix the bloated balloon on the straw with scllotape.

When releasing the balloon, it moves very quickly on the wire; due to the air expulsion, the balloon is pushed on the opposite direction.

Verifying Bernoulli’s law

We need:

– a sheet of paper
– two books



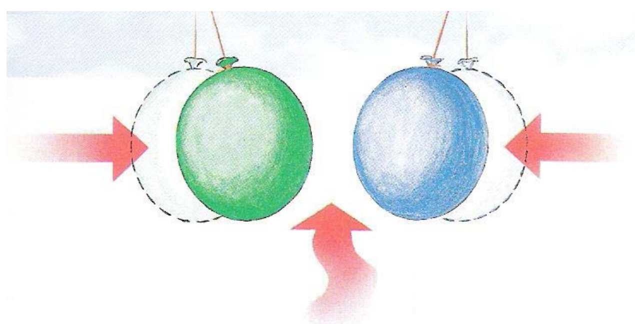
a) b)

(a) When we blow over the sheet of paper, the pressure on its top is smaller then in the stationary case because the air velocity increases. The bigger pressure from below push the paper upwards.
(b) If we put the sheet of paper onto two books and blow under it, the paper is moving downwards, because the pressure below the sheet of paper is smaller than on the top of it.

4.4 The "magic" blow

We need:

- two balloons
- a wire
- a straw



When we blow air with the straw between the two balloons, the pressure of static air around the balloons is bigger then the pressure between them, and the pressure difference push the balloons one to each other.

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