Rockets !

Robert Goddard, The Father of Modern Rocketry

Robert H. Goddard, Ph.D. (Oct. 5, 1882 - Aug. 10, 1945)

A U.S. professor and scientist, he was a pioneer of controlled, liquid-fueled rocketry. He launched the world's first liquid-fueled rocket on Mar. 16, 1926. From 1930 to 1935 he launched rockets that reached speeds of up to 550 mph.

Though his work in the field was revolutionary, he was sometimes made fun of for his theories. He didn’t get a lot of recognition during his life, but would eventually be called one of the fathers of modern rocketry for his life's work.

Goddard launched the first liquid-fueled rocket on Mar. 16, 1926 in Auburn, Mass. His journal entry of the event was pretty much an understatement: “The first flight with a rocket using liquid propellants was made yesterday at Aunt Effie's farm.”

The rocket, named "Nell", went up just 41 feet during a 2.5-second flight and ended in a cabbage field. Now, it doesn’t seem so dramatic, but it showed that liquid-fuel propellants were possible.

SOME of Goddard's "firsts"

- First to explore mathematically the practicality of using rocket propulsion to reach high altitudes and even the moon (1912)
- First proved that a rocket will work in a vacuum, that it doesn't need air to push against
- First developed and shot a liquid fuel rocket, March 16,1926
- First shot a scientific payload (barometer and camera) in a rocket flight, 1929
- First used vanes in the rocket motor blast for guidance, 1932
- First developed gyro control apparatus for rocket flight, 1932
- First received U.S. patent in idea of multi-stage rocket, 1914
- First developed pumps suitable for rocket fuels
- First launched successfully a rocket with a motor pivoted on gimbals under the influence of a & gyro mechanism, 1937

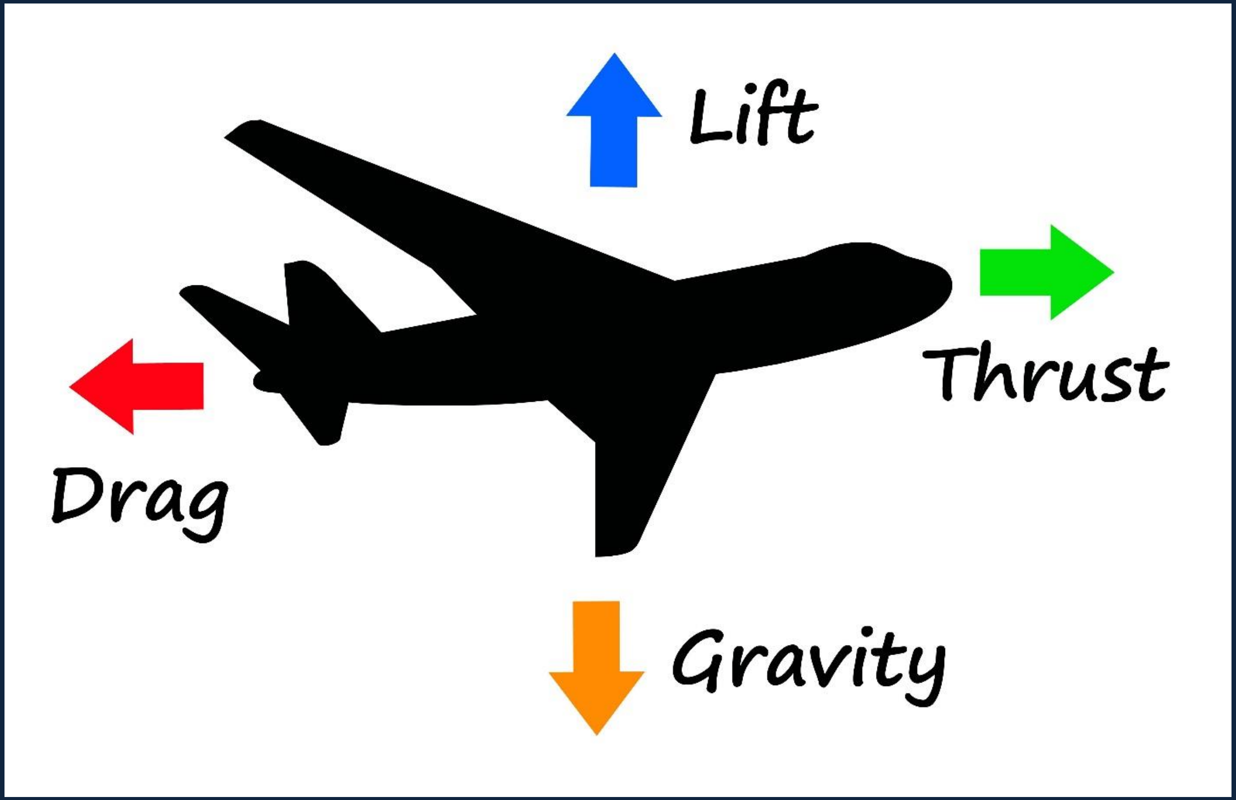
And all this before 1940!!

Homer Hickam and the "Rocket Boys"

Homer "Sonny" Hickam, Quentin Wilson, Roy Lee Cooke, and O'Dell Carroll (not pictured: Sherman Siers and Billy Rose)

October 5th, 1957 - the Soviets launched Sputnik. January 31st, 1958 - the United States launched Explorer-I. Great technical and scientific achievements that had a profound influence on the lives of several young men in Coalwood. Homer Hickam became the central figure in a group of boys at Big Creek High School who learned about, designed, constructed, and launched their own rockets. The first rocket Homer built was less than a success - pieced together with parts from a plastic airplane model and a flashlight casing, rather than soar into the air, it exploded and destroyed part of a backyard fence. This did not deter Homer and his friends. Instead, with support from a high school science teacher, help from machinists at the coal mine where his father worked as superintendent, and a driving curiosity and desire to succeed, they continued with their rocket experiments. To organize their efforts, they formed a rocket club - the Big Creek Missile Agency (BCMA) and they gave their launching area the name, Cape Coalwood. Eventually, they were able to build small rockets that could reach altitudes of several miles. Their story is recounted in the pages of the book, "*Rocket Boys*", by Homer Hickam (also published under the title, "October Sky", an anagram of rocket boys). The book became #1 on the *New York Times* bestseller list and was made into a feature film in 1999.

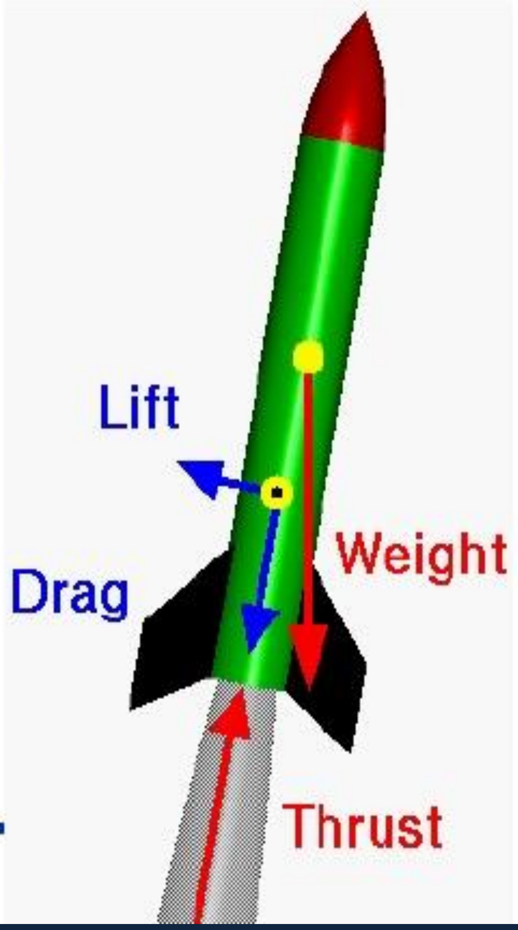
Flying rockets is a science! Just like a flying airplane, a model rocket is subjected to the forces of weight, thrust, and the aerodynamic forces lift and drag. How big and in what direction the forces are determines where the rocket goes.

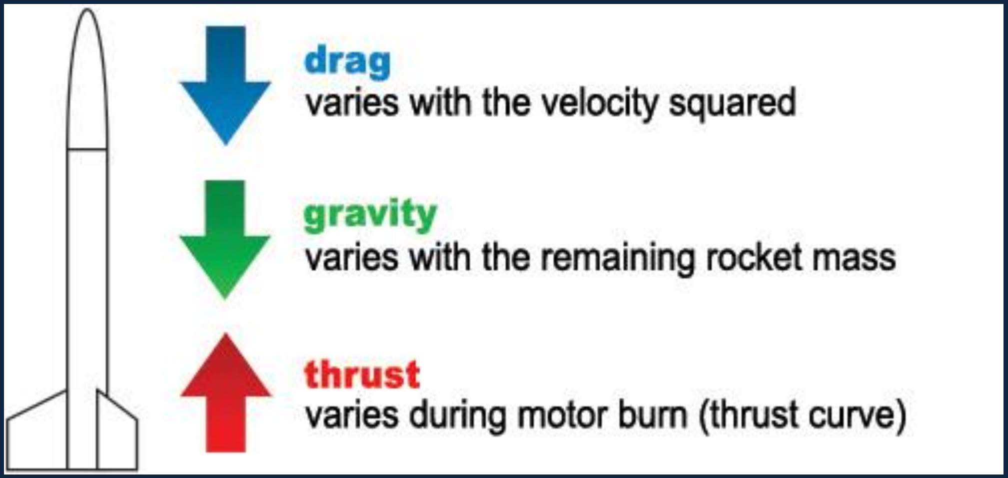


For an airplane to become airborne, the force of lift (provided mainly by the wings) must overcome the force of gravity. For the plane to move forward, the thrust (provided by the engine) must overcome the force of drag, also know as air resistance.

Aerodynamic Forces

- On an airplane, most aerodynamic force are generated by the wings and the tail surfaces
- On a rocket, aerodynamic forces are generated by the fins, nose cone, and body tube (airframe)




drag
varies with the velocity squared
gravity
varies with the remaining rocket mass
thrust
varies during motor burn (thrust curve)

Newton's Laws and Model Rockets

Law 1 – An object at rest stays at rest and an object in motion stays in motion at a constant speed and in a straight line unless acted on by an unbalanced force.

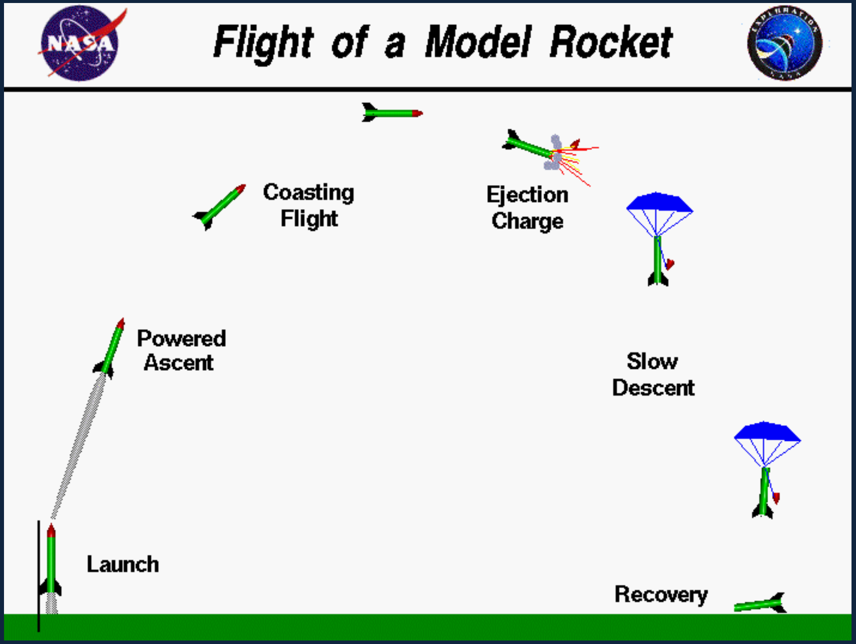
An unbalanced force must be exerted for a rocket to lift off from a launch pad.

Law 2 – The acceleration of an object depends on the mass of the object and the amount of force applied.

The amount of thrust (force produced by a rocket engine) will be determined by the mass of rocket fuel that is burned and how fast the gas escapes the rocket.

Law 3 – Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

The reaction, or motion, of the rocket is equal to and in an opposite direction from the action, or thrust, from the engine.



At launch, the thrust of the rocket engine is greater than the weight of the rocket so the net force accelerates the rocket away from the launch pad. The rocket then begins a powered ascent. Thrust is greater than weight, so the rocket keeps going up, and the aerodynamic forces of lift and drag also act on the rocket.

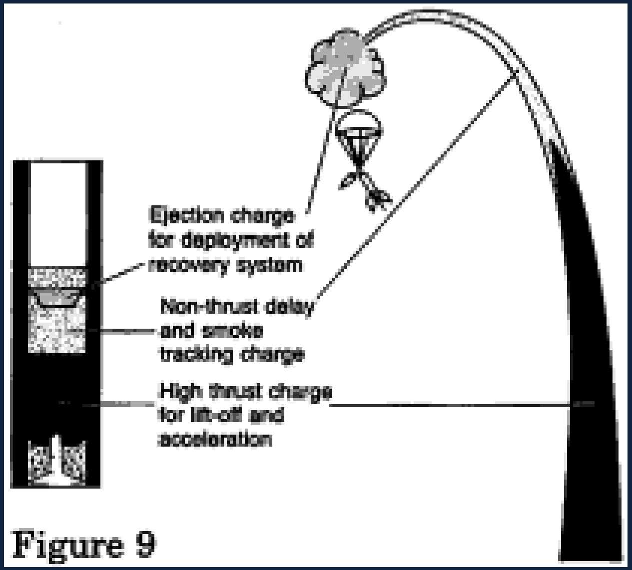
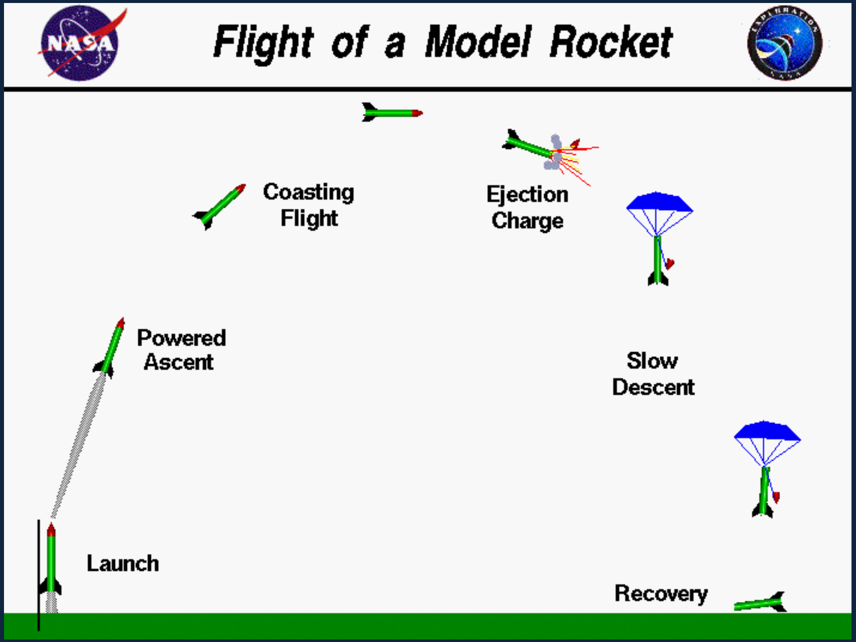


Figure 9

When the rocket runs out of propellant, (fuel), thrust is no longer present, and the rocket enters a coasting flight. The vehicle slows down due to its weight and drag.



The rocket eventually reaches its maximum altitude, then begins to fall back to earth under the power of gravity. After the rocket burns through the delay charge, an ejection charge is ignited which pressurizes the body tube, blows the nose cap off, and deploys the parachute. The rocket then begins a (hopefully) slow descent under the parachute or with a streamer. After recovering the rocket, you can replace the engine and fly again.

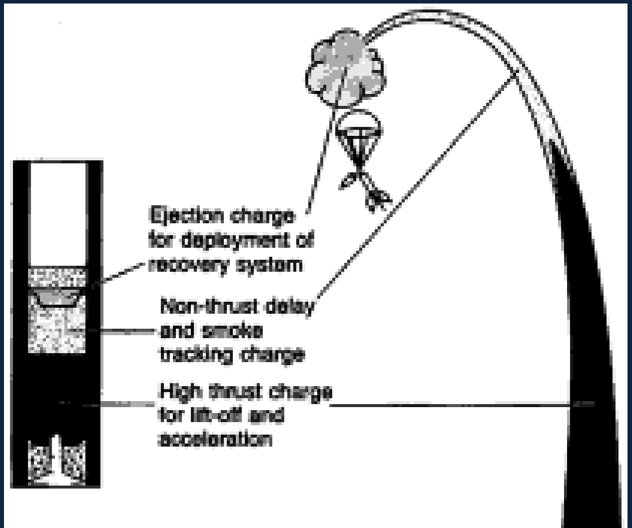


Figure 9

Model Rockets and Real Rockets

Compare and Contrast

Model Rocket

4 forces throughout flight

all of flight in atmosphere
aerodynamics very important

very short powered flight

solid rocket engine
small propellant mass fraction

passive stability
no control

low speed
heating not important

inexpensive materials
balsa, cardboard, plastic

Real Rocket

4 forces during atmospheric flight

short time in atmosphere
aerodynamics less important

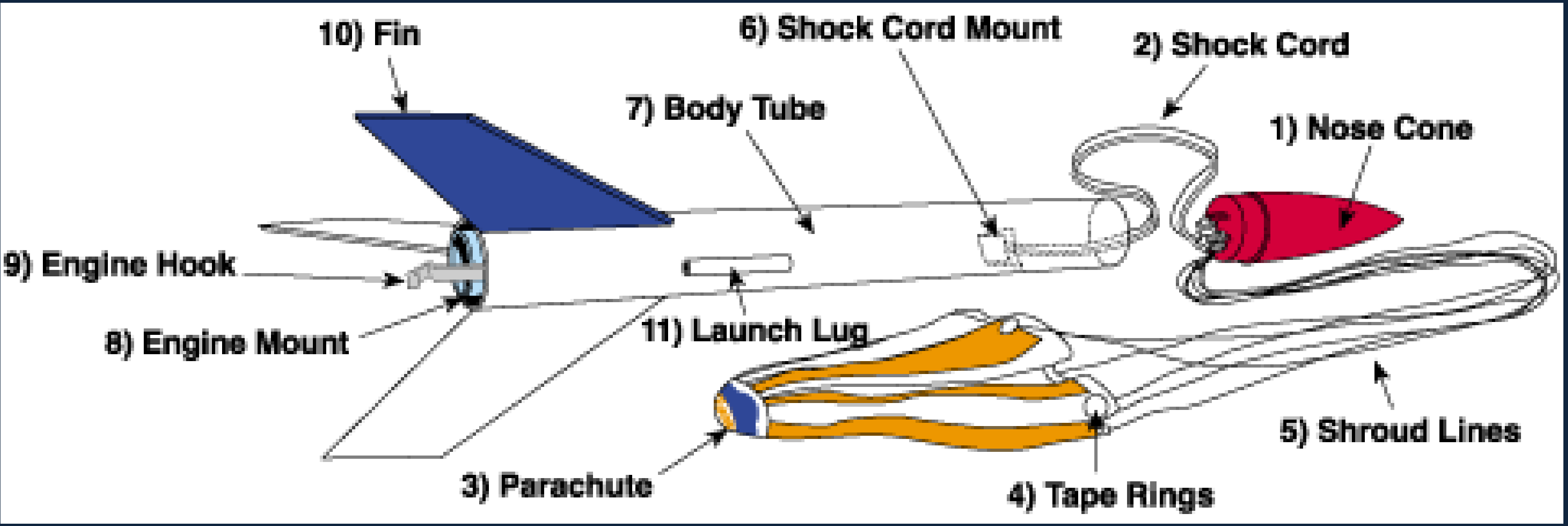
long powered flight

liquid or solid rocket engine
large propellant mass fraction

passive stability
active control

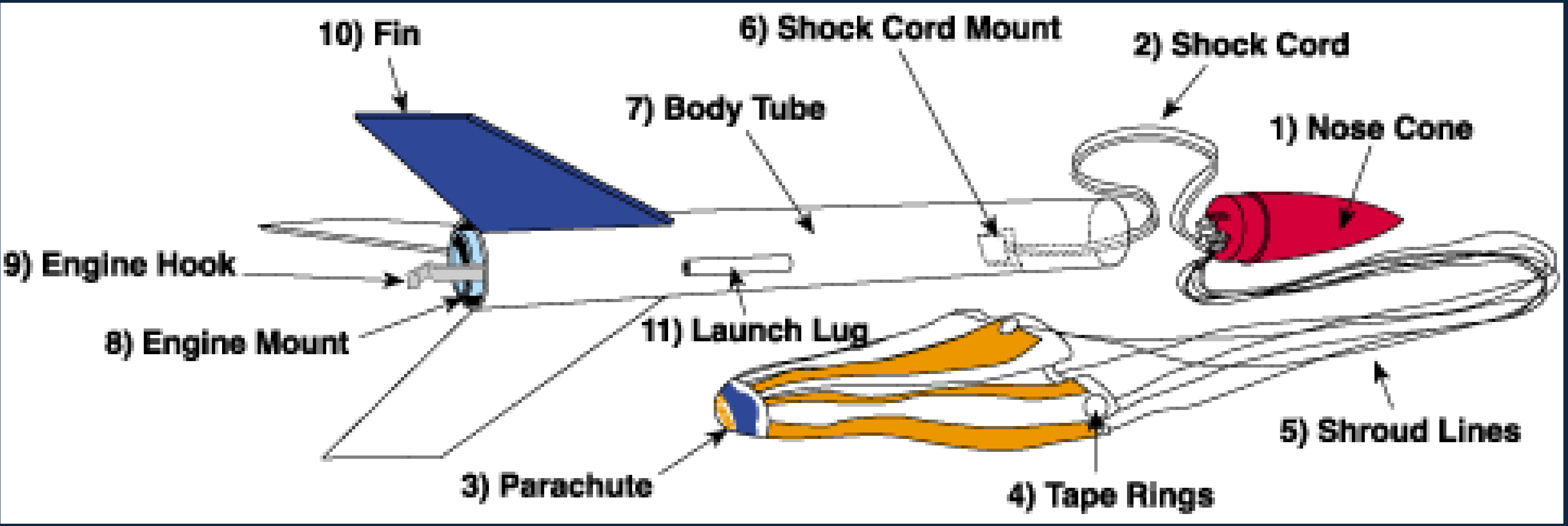
high speed
heating important

expensive materials
aluminum, titanium, nickel alloy

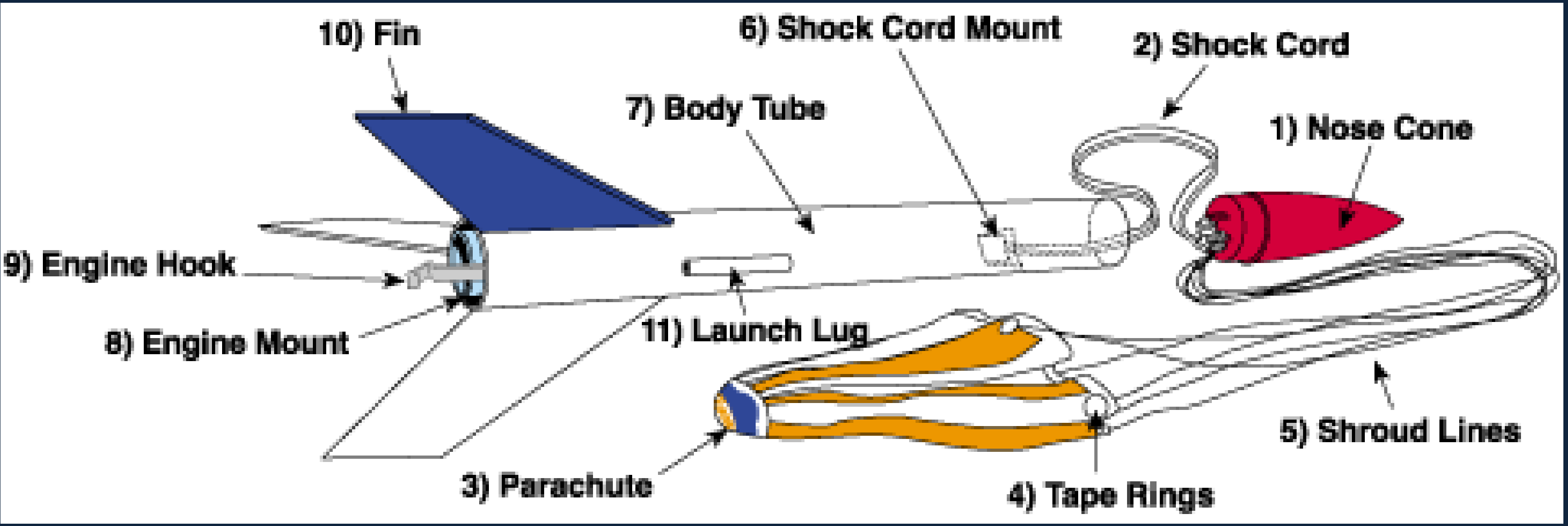


Parts of a Single Stage Model Rocket:

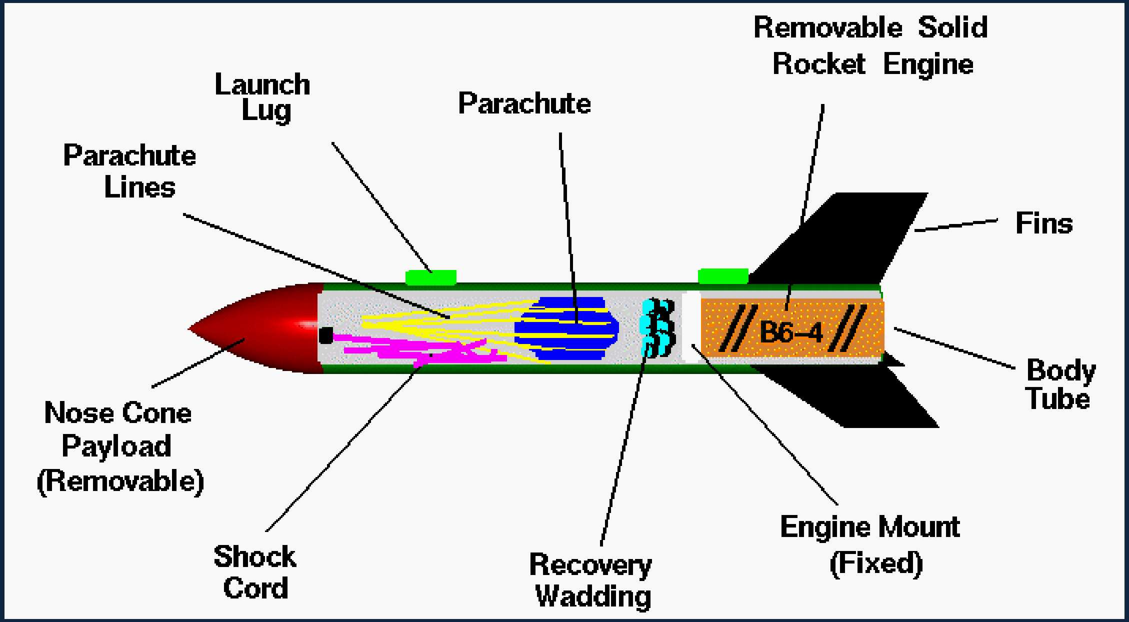
1) Nose Cone: The nose cone can be made of balsa wood, or plastic, and may be either solid or hollow. The nose cone is inserted into the body tube before flight.
2) Shock Cord: An elastic shock cord is connected to both the body tube and the nose cone and is used to keep all the parts of the rocket together during recovery.
3) Parachute: The recovery system consists of a parachute or a streamer. Parachutes and streamers are made of thin sheets of plastic.



4) Tape Rings: Reinforcements to keep the shroud lines from tearing the parachute. (like notebook page reinforcers)
5) Shroud Lines: Lines to connect the parachute to the nose cone.
6) Shock Cord Mount: Attaches the shock cord to the body.
7) Body Tube: a cardboard tube with fins attached at the rear.
8) Engine Mount: Transmits the thrust of the engine to the body of the rocket, and is fixed to the rocket. It can be made of heavy cardboard or wood and has a hole through it to allow the body tube to be pressurized to eject the nose cone and the recovery system.

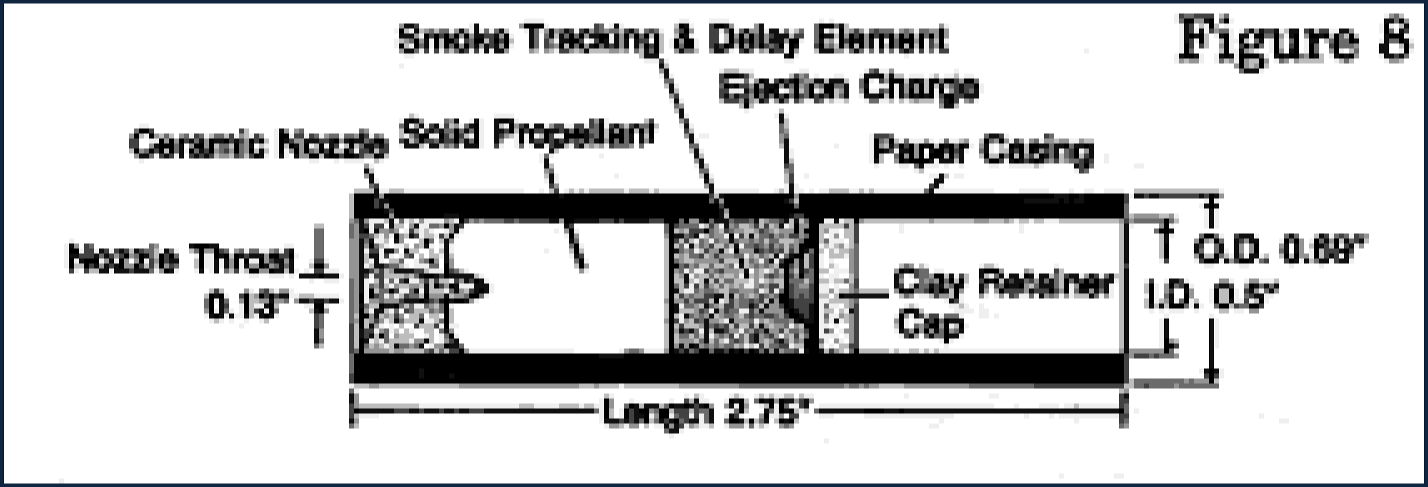


9) Engine Hook: Keeps the engine from falling out of the body of the rocket.
10) Fin: The fins can be made of either plastic or balsa wood and are used to provide stability during flight.
11) Launch Lug: These are small tubes (straws) which are attached to the body tube. The launch rail is inserted through these tubes to provide stability to the rocket during launch.



Other Parts:

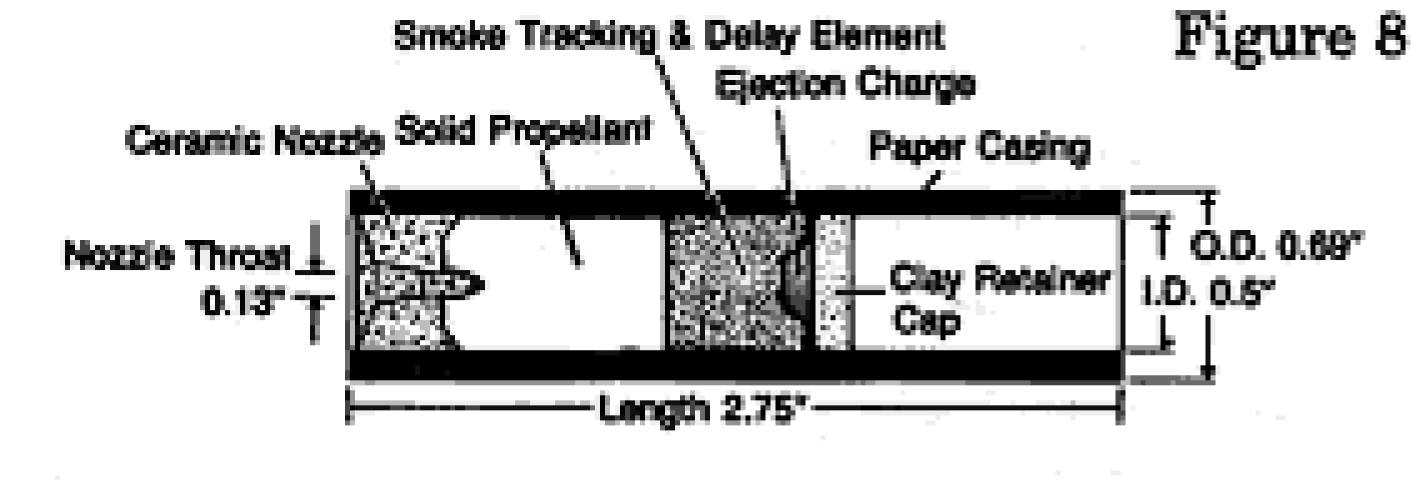
1) Engine: Model rockets use small, pre-packaged, solid fuel engines. The engine is used only once, and then is replaced with a new engine for the next flight. Engines come in a variety of sizes, which can affect how high the rocket flies. (Hang on for more on engines…)
2) Recovery wadding is inserted between the engine mount and the recovery system to prevent the hot gas of the ejection charge from damaging the recovery system.



Model Rocket Engines

The engine casing is a cylinder made of heavy cardboard which contains the nozzle, propellants, and other explosive charges. On one end of the engine is the nozzle, which is used to accelerate hot gases and produce thrust. Model rocket nozzles are usually made of clays or ceramics because of the high temperature of the exhaust.

The hot gases for a model rocket are produced by the solid propellant, and ignited by an electric igniter. As the flame burns through the propellant, the rocket is launched, and flies.



When the flame reaches the delay element, the rocket stops accelerating. During this delay, no more thrust is produced and the rocket coasts up to its maximum altitude. In the delay element is also a substance that causes a smoke trail, making it easier to track your rocket.

When the delay charge is completely burned through, the ejection charge is ignited. This produces a small explosion which ejects hot gas out the front of the engine through the engine mount, ejects the nose cone, and deploys the parachute for a safe recovery.

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