AST 312 Rocket Propulsion Introduction

NASA

Syllabus

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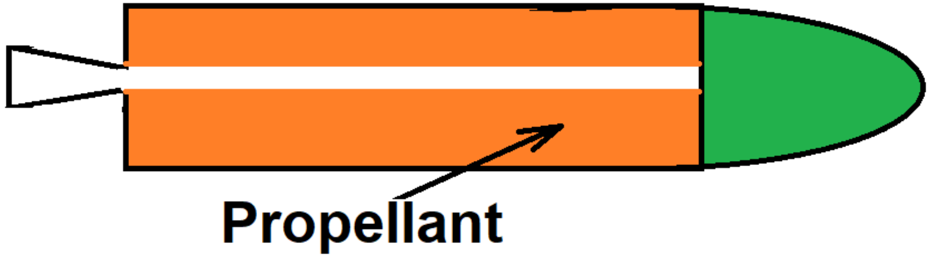
Propulsion

- Definition: Act of changing the motion of a body
- Propulsion mechanism provide force which
  - –Change velocity
  - –Change direction
- Jet propulsion a reaction force is imparted to a device by the momentum of ejected matter.
  - –Rocket propulsion produces thrust by ejecting stored matter, called the propellant.
  - –Rockets carries own fuel and oxidizer to generate thrust.
  - –Can operate outside of the Earth's atmosphere.
  - –Duct propulsion utilize surrounding medium and stored fuel such as turbojets and ramjets; these engines are also commonly called airbreathing engines.

Max altitude 15 km



Chemical Rocket Propulsion

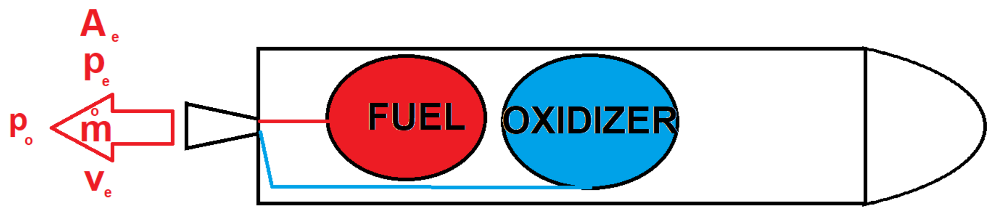
- The energy from a high-pressure combustion reaction of propellant chemicals, usually;
  - –a fuel and
  - –an oxidizing chemical,

permits the heating of reaction product gases to very high temperatures (2500 to 4100 C).

•These gases subsequently are expanded in a nozzle and accelerated to high velocities (1800 to 4300 m/s).

•Since these gas temperatures are about the twice the melting point of steel, it is necessary to cool or insulate all the surfaces that are exposed to the hot gases.

$$F = \dot{m}V_e + (p_e - p_0)A_e$$

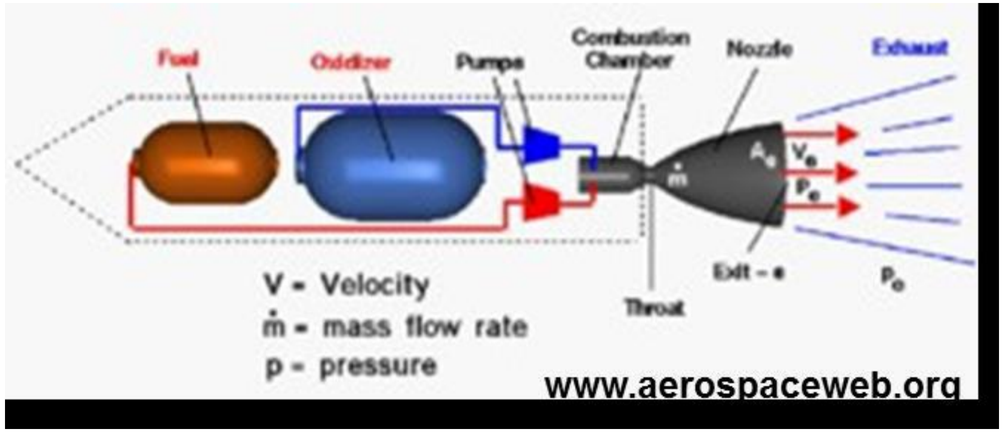


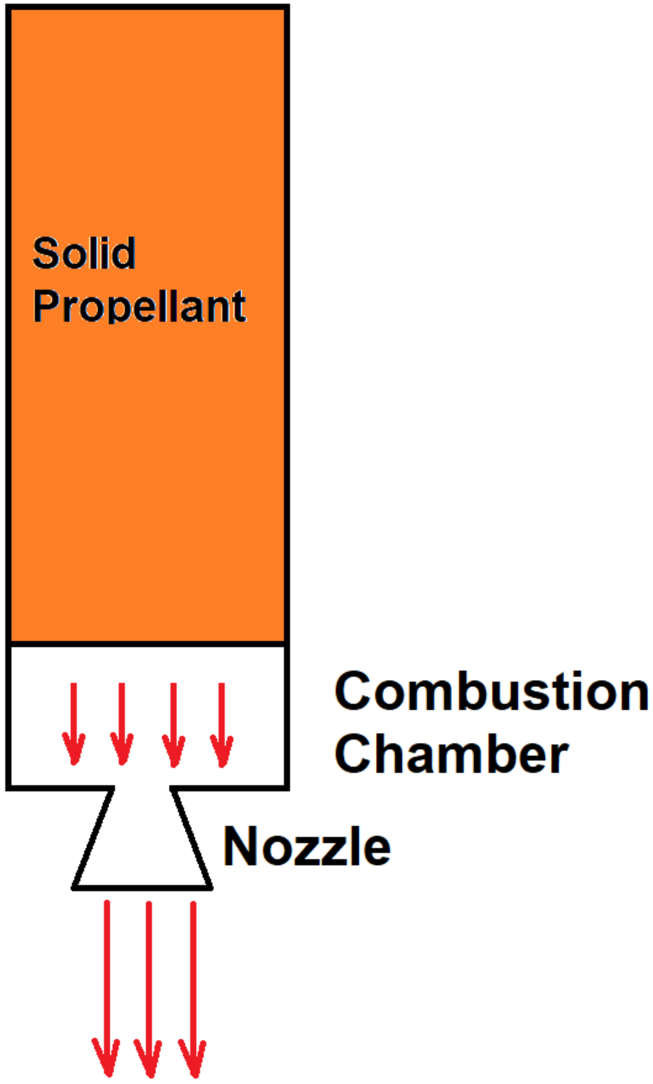
Liquid Propellant Rocket Engine

Liquid propellant rocket engines use liquid propellants that are fed under pressure from tanks into a combustion chamber.

- In the combustion chamber the propellants react to form hot gases.
- These gases are accelerated and ejected at high velocity through a supersonic nozzle.

Nozzle: converging-throat-diverging





Solid Propellant Rocket Motor

The propellant to be burned is contained within the combustion chamber or case.

•The solid propellant charge is called the **grain** and it contains all the chemical elements for complete burning.

•Once ignited, it usually burns smoothly at a predetermined rate on all the exposed internal surfaces of the **grain**.

•The internal cavity grows as propellant is burned and consumed.

•The resulting hot gas flows through the supersonic nozzle to impart thrust.

•Once ignited, the motor combustion proceeds in an orderly manner until essentially all the propellant has been consumed.

•There are no feed systems or valves.

Gaseous Propellant Rocket Engines

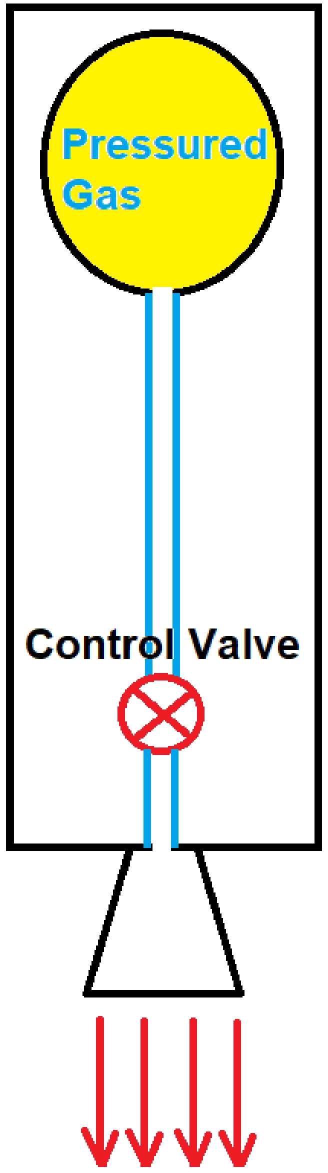
Use high-pressure gas such as air, nitrogen, or helium.

•Requires relatively heavy tanks.

•These **cold gas engines** have been used on many early space vehicles for low thrust maneuvers and for attitude control systems.

•Some are still used today.

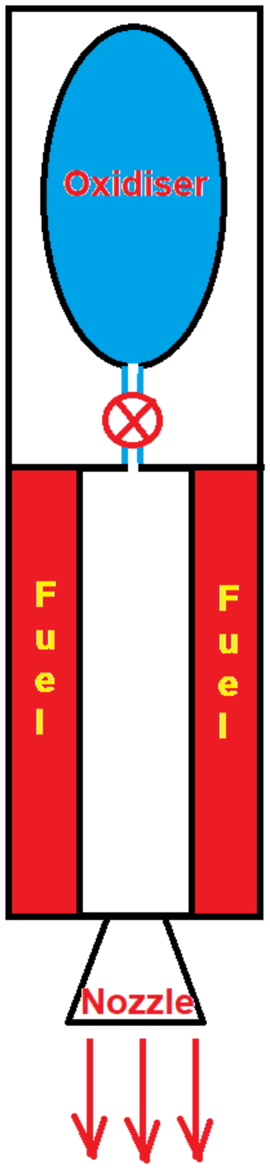
•Heating the gas improves the performance and called **warm gas propellant rocket propulsion**.



Hybrid Propellant Rocket Propulsion Systems

These systems use both liquid and a solid propellant.

•If a liquid oxidizing agent is injected into a combustion chamber filled with a solid carbonaceous fuel grain, the chemical reaction produces hot combustion gases.



Nuclear Rocket Propulsion

Two different types of nuclear energy sources have been investigated for delivering heat to a working fluid, usually liquid hydrogen, which subsequently can be expanded in a nozzle and thus accelerated to high ejection velocities (6000 to 11.000 m/sec).

–Fission reactor

–Fusion reactor

•However, none can be considered fully developed today and none have flown.

•Both are basically extensions of liquid propellant rocket engines.

•The heating of gas is accomplished by energy derived from transformations within the propellants.

•But in nuclear rockets the power source is usually separate from the propellant.

Nuclear Rocket Propulsion

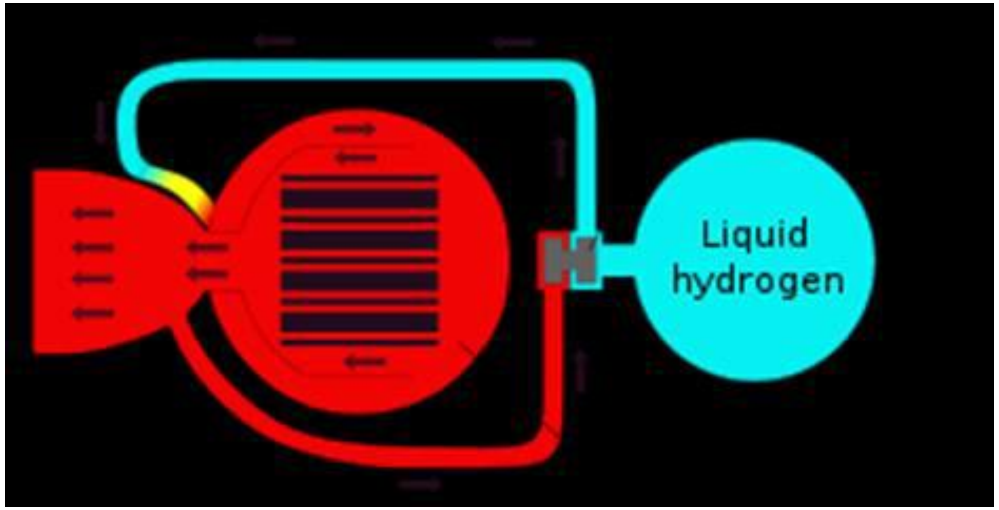
In the nuclear fission reactor rocket, heat can be generated by the fission of uranium in the solid reactor material and subsequently transferred to the working fluid .

•The nuclear fission rocket is primarily a high-thrust engine (above 40,000 N) with specific impulse values up to 900 sec.

•Fission rockets were designed and tested in the 1960s.

•Ground tests with hydrogen as a working fluid culminated in a thrust of 980,000 N at a graphite core nuclear reactor level of 4100 MW with an equivalent altitude-specific impulse of 848 sec and a hydrogen temperature of about 2500 K.

•There were concerns with the endurance of the materials at the high temperature (above 2600 K) and intense radiations, power level control, cooling a reactor after operation, moderating the high energy neutrons, and designing lightweight radiation shields for a manned space vehicle.



Electric Propulsion

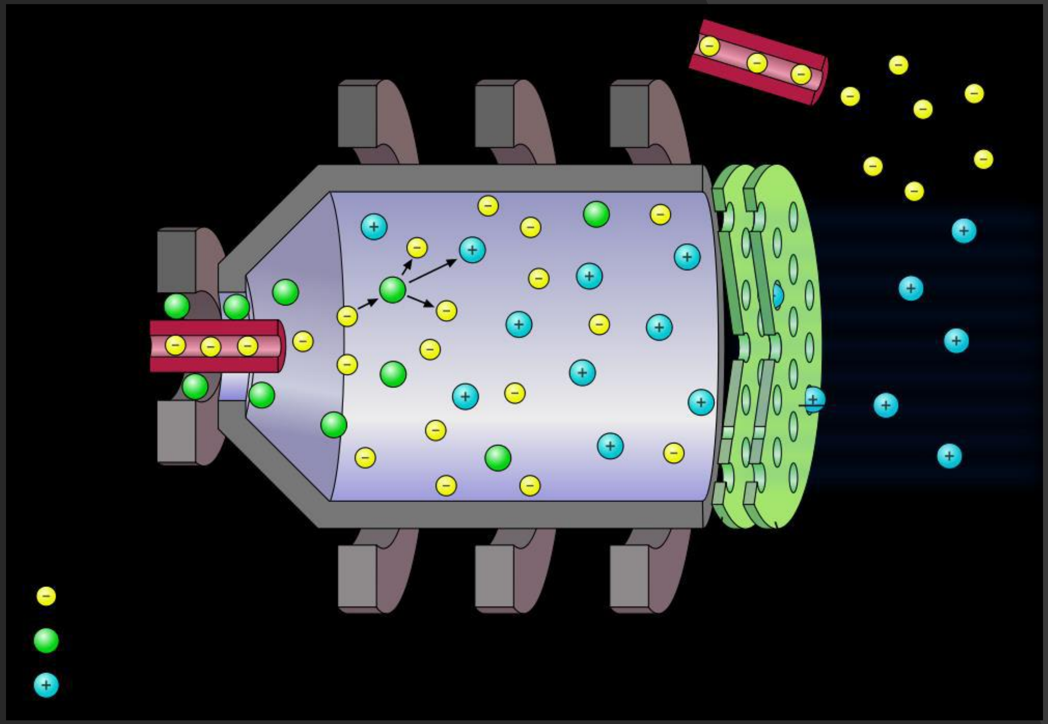
The two types are the **electrostatic or ion propulsion engine** and the **electromagnetic or magnetoplasma.**

•Both will work only in a vacuum.

•In an ion rocket a working fluid (typically, xenon) is ionized (by stripping off electrons)and then the electrically charged heavy ions are accelerated to very high velocities(2000 to 60,000 m/sec) by means of electrostatic fields.

•The ions are subsequently electrically neutralized.

•They are combined with electrons to prevent the buildup of a space charge on the vehicle.



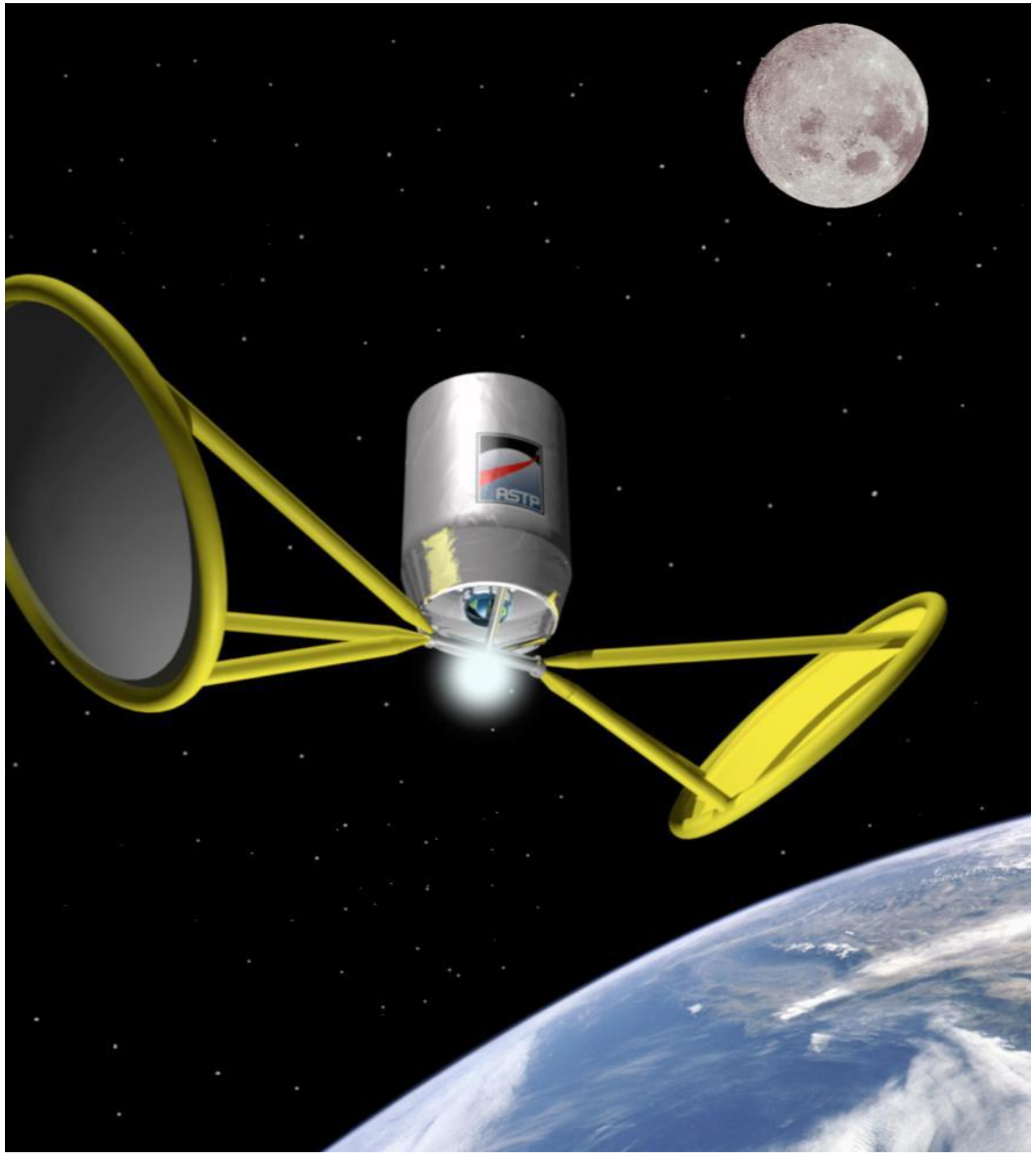
Solar Thermal Rocket

The solar thermal rocket, has large diameter optics to concentrate the sun's radiation (e.g., by lightweight precise parabolic mirrors or Fresnel lenses) onto a receiver or optical cavity.

•It heats a working fluid, usually liquid hydrogen, up to perhaps 2500°C and the hot gas is controlled by hot gas valves and exhausted through one or more nozzles.

•The large mirror must be pointed toward the sun, and this requires the mirror to be adjustable in its orientation.

•To date the solar thermal rocket has not yet provided the principal thrust of a flying spacecraft.



Solar Sail

The solar sail is another concept.

•It is basically a big photon reflector surface.

•The power source for the solar sail is the sun and it is external to the vehicle.

•Concepts for transmitting radiation energy (by lasers or microwaves) from earth stations to satellites have been proposed but are not yet developed.