

# Modern Space Propulsion

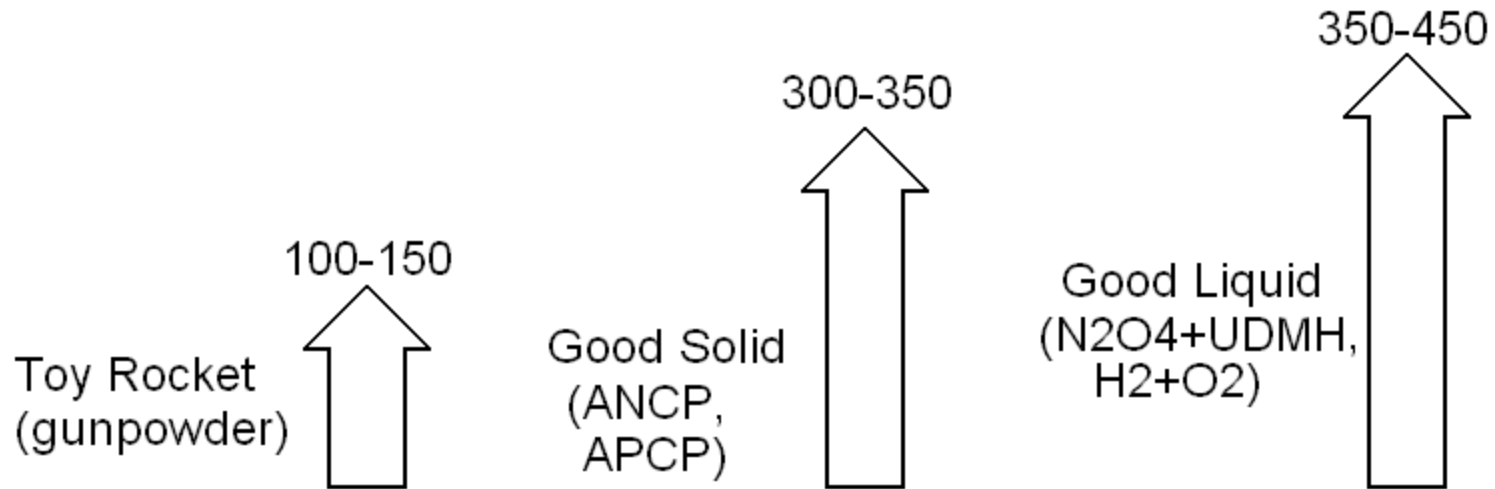
by Deuce =^.^=.

(art by Modem - modem\_redpill@yahoo.com,  
<http://www.furaffinity.net/user/modemredpill>)

# Key Concepts: Delta-V

- Delta-V for a rocket is like the range of a car: it tells you where you can and can't go.
- Burn your fuel all at once or bit by bit; same result.
- Earth to orbit: 8 km/sec
- Earth escape: 11 km/sec
- Exploring the solar system: 10-30 km/sec

# Key Concepts: Specific Impulse

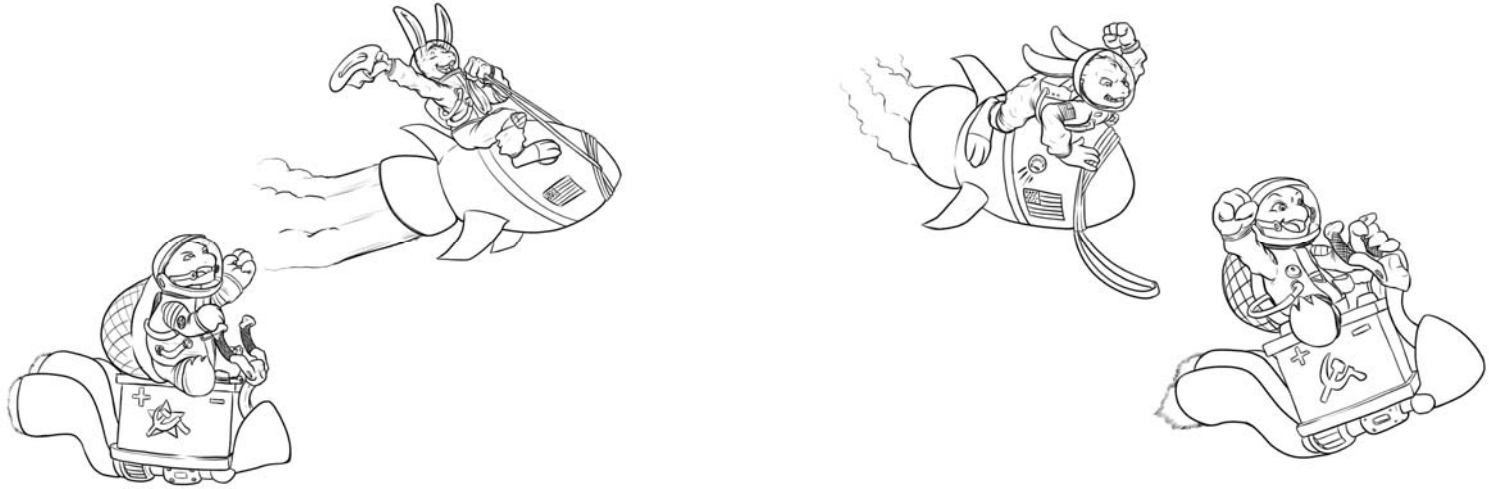


- Isp = Pound-seconds of thrust per pound of propellant.
  - This is the most important stat for rocket fuels!
- Exhaust velocity ( $V_e$ ) =  $9.8 * I_{sp}$

# Going Fast is Hard!

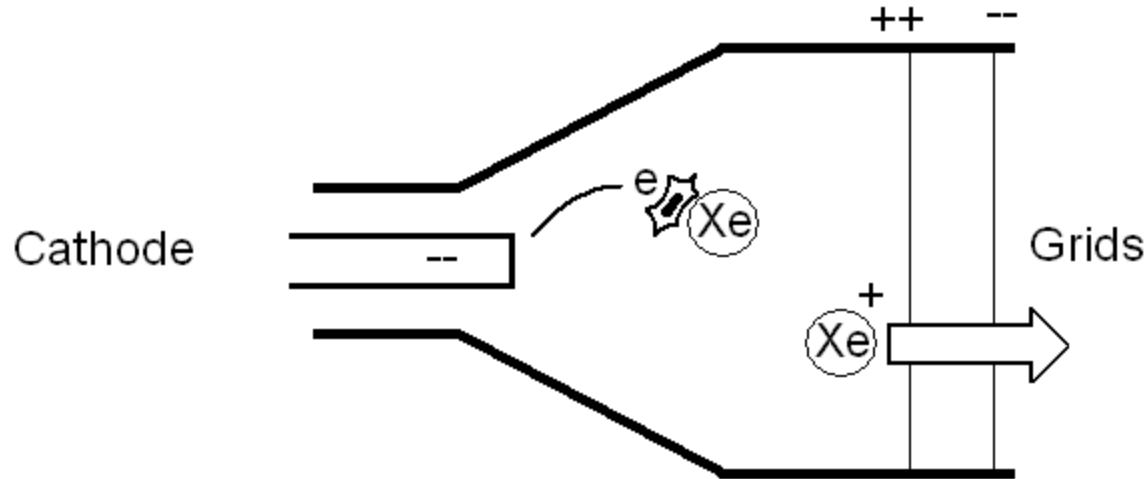
- Rocket Equation:
  - $\Delta V = V_e * \ln(\text{wet mass} / \text{dry mass})$
  - 2x  $V_e$ : 86% fuel
  - 3x  $V_e$ : 95% fuel
- Very hard just to launch from Earth!
  - 8km/sec with LOX+RP1 is >90% fuel.
  - 11 km/sec with solid fuel is >98% fuel!
- To get 30 km/sec, need better than chemical Isp.

# Modern Solution: Electric Drives



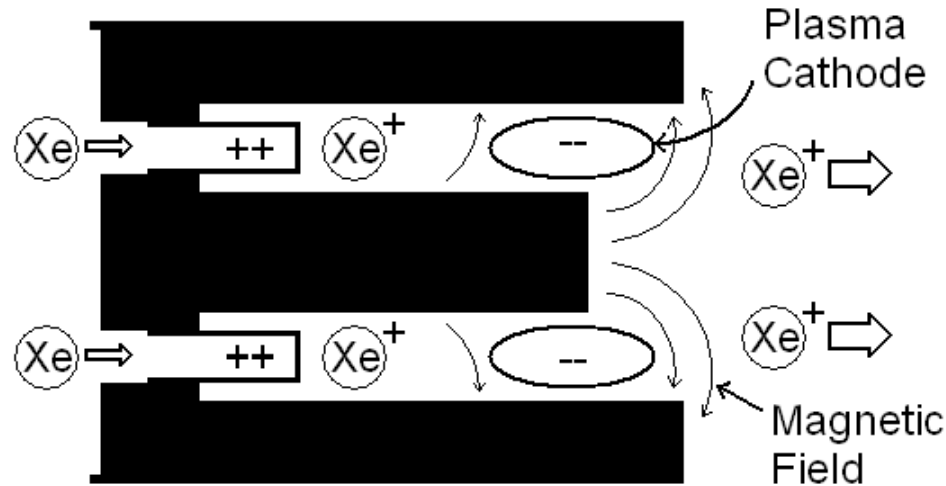
- Chemical rockets have high thrust, poor Isp.
- Electric rockets have low thrust, but better Isp (3000-6000).
- Common types:
  - Ion thrusters, Hall effect thrusters, Plasma thrusters

# Ion Thrusters



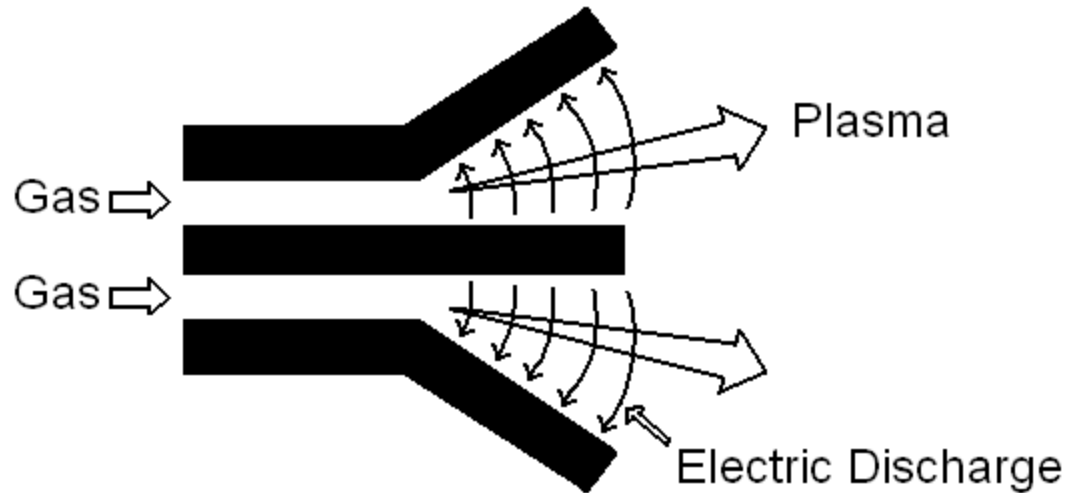
- Electrostatic accelerator, like a vacuum tube.
- Impact ionization makes ions.
- Screens accelerate ions.
- Low thrust, but long-lived and power-efficient.

# Hall Effect Thrusters



- Uses a plasma cathode (no cathode wear).
- Hall effect heats the plasma, which ionizes propellant.
- Shorter life (due to plasma etching), but higher thrust and still power-efficient.

# MPD Plasma Thrusters

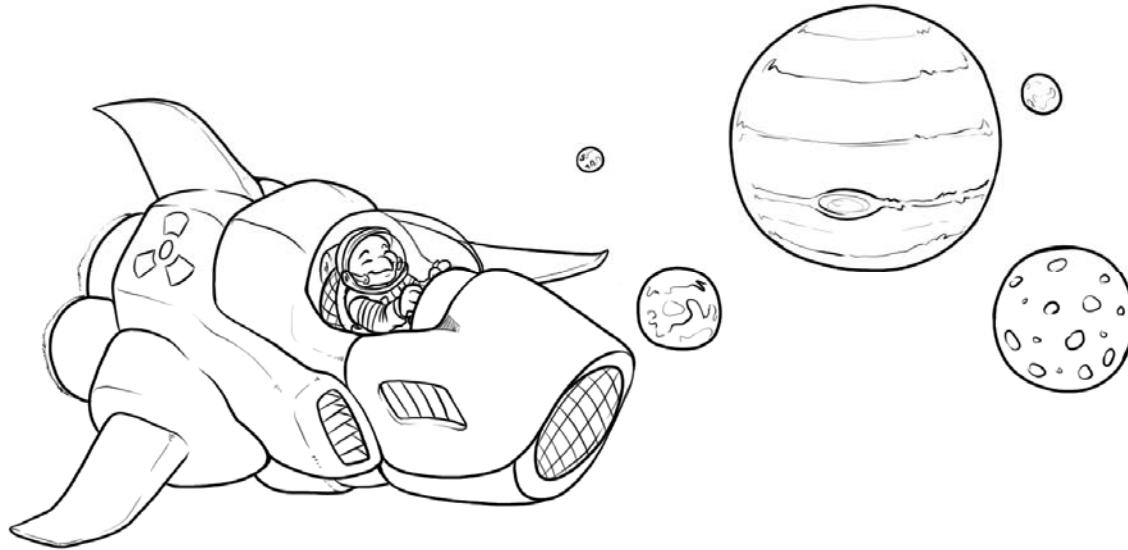


- Lorentz force accelerates, like an electric motor.
- Plasma carries the current (like motor windings).
- High thrust, but worse power efficiency and short lifetime (electrodes corrode quickly).

# Where Are We Now?

- Ion drives used by US space probes.
  - DS1
  - Dawn
- Hall thrusters used by Russian satellites.
  - Widely used for station-keeping instead of chemical thrusters.

# Looking Forward



- Next step is an electric thruster with nuclear power.
- JIMO (Jupiter Icy Moons Orbiter) proposal would have done this (cancelled in 2005).