Recap

- V_c = space between injector & throat
- chamber must be long enough for fuel/ox to (evap.)/mix/react

Time spent by propellant in chamber

$t_s \equiv$ stay time / transit time / residence time

Necessary t_s depends on

- Fuel / oxidizer form (liquid, gas, gel)
- Fuel - oxidizer chemistry
- injector geometry
- shape of combustor

Basic relations

- $V_c = \frac{\dot{m}}{\rho_{avg}} t_s$

ρ_{avg} some average density of propellant

- characteristic length

$L^* \equiv \frac{V_c}{A^*}$ useful as reference length

$L^* >$ actual length of CC
(injector to throat distance)

The longer the CC, the more complete the combustion

$\Rightarrow T_0$ higher

$\Rightarrow$ higher char. velocity $c^* \sim \sqrt{T_0}$

From Fig. 4.7 $L^* \uparrow \rightarrow c^* \uparrow$ true up to some L^*_{max}

past that, c^* seems = const.

$\rightarrow$ higher L^* bad for weight & increased friction losses

To "design" a comb. chamb., start from L^* from past experience.

Residence times corresponding to L^* in table in handout.

$$2 \cdot 10^{-3}\, s \le t_s \le 40 \cdot 10^{-3}\, s$$

__Operationally__

- Pick J, P_o, C_J, C^*, I_{sp}, L^*
  - → calculate A^*
- To determine (final) dimensions of cc (V_c)
- Choose shape (most commonly cylindrical)
- " " of contraction profile (avoid sharp corners)
- Based on L^*, A^*, determine

$$\text{contraction ratio} \equiv \left(\frac{D_{cc}}{D^*}\right)^2 = \frac{A_{cc}}{A_t} = \varepsilon_c$$

__Remarks__

- large engines (i.e. large A^*)(Saturn V, SSME)
  - low ε_c
  - large L^*
- small engines (small A^*)(RCS thrusters)
  - high ε_c
  - small L^*
- contraction ratio ↓ as D_t ↑

  If it didn't, D_{cc} would become impossibly large

- $L_c \uparrow$ as $D_t \uparrow$

  If it didn't, imagine $D_t = 25$ in

  then from fig. 4.9 $\varepsilon_c \sim 2$ $\rightarrow D_{cc} \sim \sqrt{2}\,50 \simeq 70''$

  would be impossible to go from 70" to 25" over a length of just a few inches