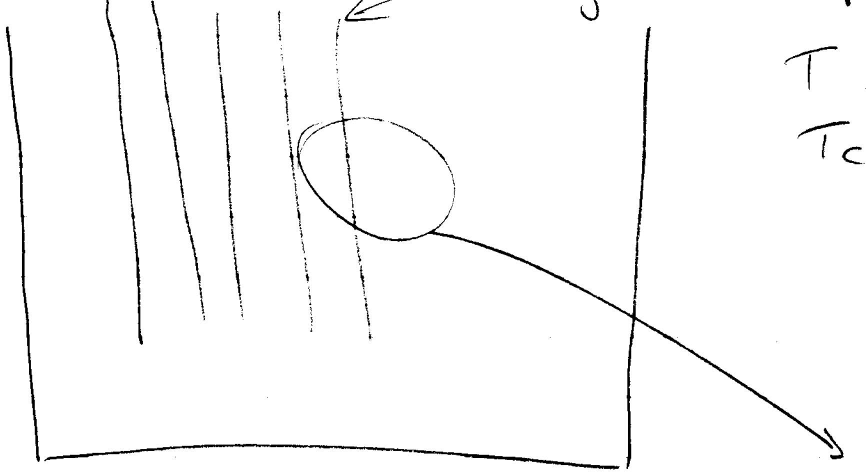
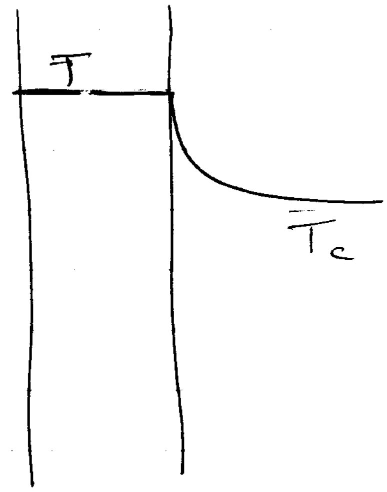
8.

long thin fuel pencils, k_f large.



T = fuel temp

T_c = coolant temp.



$$\rho = \rho_0 + \overbrace{\frac{\partial \rho}{\partial T}}^{\equiv -\alpha}(T - T_0)$$

(ie as temp. of fuel changes from base case, the crosssections change, hence changing the effective ρ. The neutron density, hence power, will subsequently change via:

$$\frac{dn}{dt} = \frac{\rho - \beta}{\Lambda} n(t) + \sum_i \lambda_i C_i$$

1 mk ρ is added $\Rightarrow$ power $\uparrow$, $\therefore$ $T \uparrow$ $\therefore$ feedback to ρ occurs. Power will rise until 1 mk negative ρ is added by temp. feedback, then the power levels off since net $\rho = 0$.

Have $h_s(T - T_c) = q'' = \dfrac{w_a \Sigma_a \phi V}{A}$ — Total heat produced / Total surface area.

$$\therefore T - T_c = \frac{w_a \Sigma_a n v V}{A h_s} \equiv a \cdot n$$

$$\therefore \rho = \rho_0 - \alpha(an + T_c - T_0)$$

at Power P_o, $T = T_o \Rightarrow$ $T_o - T_c = a\, n_o$

Then 1 mk is ~~added~~ (ie $\rho_o = 1$ mk)

$$\therefore \quad \rho = 1\text{ mk} - \alpha\,(a n + T_c - T_o)$$

$$= .001 - \alpha\,(a n - a n_o)$$

$\rho > 0$ $$= .001 - \alpha a\,(n - n_o)$$

& n increases until $\rho = 0$

$$\text{ie} \quad 0 = .001 - \alpha a\,(n - n_o)$$

$$\therefore \quad \cancel{\alpha a}\,(n - n_o) = \frac{.001}{\alpha a}$$

$$\boxed{\therefore \quad n = n_o + \frac{.001}{\alpha a}} \quad (b)$$

But $T - T_c = a n \quad \therefore \quad T = T_c + a\left(n_o + \dfrac{.001}{\alpha a}\right)$

$$= T_c + a n_o + \frac{.001}{\alpha}$$

$$\boxed{T = T_o + \frac{.001}{\alpha}} \quad (a)$$

Or given $\alpha = \dfrac{\partial \rho}{\partial T}$, immediately $\rho = \rho_o + \dfrac{\partial \rho}{\partial T}(T - T_o)$

or $\Delta\rho = \dfrac{\partial \rho}{\partial T}\,\Delta T \quad \therefore \quad \Delta T = \dfrac{\Delta \rho}{\frac{\partial \rho}{\partial T}} = \dfrac{-.001}{-\alpha} = \dfrac{.001}{\alpha}$

& then calc n to give that ΔT.