16.522 Space Propulsion
Homework #5

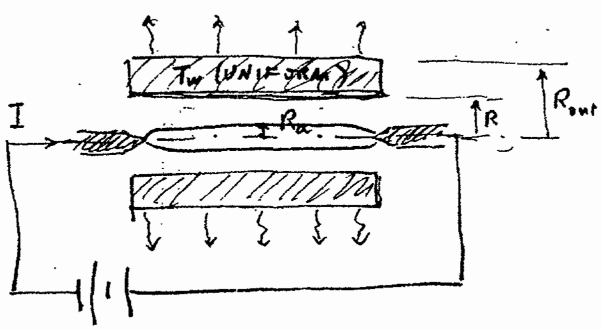
Handed: 3/4/04
Due: 3/11/04

Problem 1

Using the simple model of ionization/conduction developed in class, calculate and plot versus *T(K)* the quantities $n(m^{-3}), S(m^{-3}), n_e(m^{-3}), \alpha = \frac{n_e}{n_n + n_i}$ (degree of ionization), $\bar{c}_e\left(\frac{m}{s}\right), \nu_{en}(s^{-1}), \nu_{ei}(s^{-1}), \nu_e(s^{-1})$ and $\sigma(Si/m)$. Cover the range 5,000K ≤ T ≤ 16,000K. Compare to the more complete results in Yos' graph handed out in class. Take $P = 1$ atm.

Problem 2

Using the simplified formulation covered in class calculate the maximum current in an arc burning inside a radiatively cooled constrictor, the walls of which are limited to a Maximum temperature $(T_W)_{MAX}$. Assume the constrictor is long enough that the end effects are negligible. There is no flow around the arc. The body of the constrictor is made of a good thermal conductor, and can be assumed to be isothermal, at $T=T_w$. The outside surface radiates to space at a rate $\varepsilon\sigma T_w^4$ per unit area (ε is the emissivity, and $\sigma = 5.67\times10^{-8}\, w/m^2/K^4$ is Stefan-Boltzmann's constant).



NOTE: Try to arrange your expression in the form $I^* = \lambda f(y)$ where

$y = \beta\frac{T_w^{*4}}{1-T_w^*}$; $T_w^* = \frac{T_w}{T_e}$; $\beta = \frac{\varepsilon\sigma T_e^3 R_{out}}{K_{out}}$ and other symbols are as defined in class.

Calculate the allowable current for the case:
$\overline{K} = 1\ w/m/K$; $K_{out} = 0.2\ w/m/K$ (gas thermal conductivities inside and outside arc).
$\varepsilon = 0.8$; $T_e = 7000K$; $R_{out} = 1cm$; $R = 3mm$.
T_w=2000K (max allowable)
a=0.5 Si/m/K