MAE 150R
Rocket Propulsion Systems
Assignment 5: Due Monday, June 5, 2000
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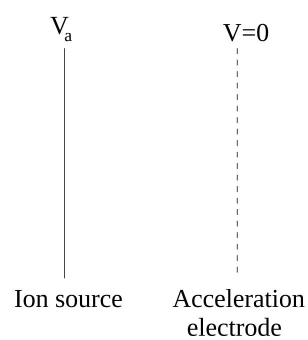
1. An electrostatic rocket is to use a propellant with a charge-to-mass ratio q/m of 500 Coulombs/kg to produce a specific impulse I_{sp} of 3000 sec.

   a.) What is the voltage difference V_a that is required to achieve this acceleration of particles for the given I_{sp}?

   b.) What is the limiting current j for this beam of ions if the maximum allowable voltage gradient across the electrodes is $V_a/L = 10^5$ V/cm?

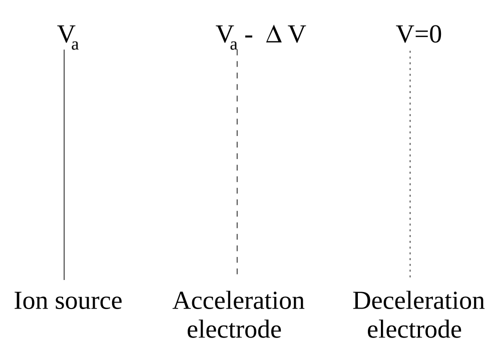
   c.) If the ion beam produces a thrust T of 0.5 N, what is the diameter of the ion beam?

2. A Xenon ion rocket is to be designed to produce a thrust of 5 N with a specific impulse of 5000 sec. The limitations on the design are: 1) minimum electrode spacing $L = 5$ mm and 2) maximum allowable voltage gradient across the electrodes $V_a/L = 10^5$ V/cm. The acceleration process is shown below.



   a.) What is the beam area A required to produce this performance?

   b.) In order to reduce this beam area, it is proposed to increase the current density by first accelerating the ions through a larger potential difference than in a.), then decelerating the ions through a deceleration electrode to achieve the desired exhaust speed for an I_{sp} of 5000 sec and a thrust of 5 N. This is shown below, where the magnitude of ΔV is greater than that of V_a:



   What is the new beam area for this configuration?

3. Consider the heat transfer processes taking place in a nuclear (fission) rocket in which there is a cosine axial power density representing propellant flow in the reactor core channels.

   a.) Show that the axial location of the maximum wall temperature T_{wm} is x_m, given by

$$tan\left(\frac{x_m \pi}{L}\right) = \frac{2c_f L}{\pi D_H}$$

   b.) Show that this produces a maximum wall temperature T_{wm} on the surface of the channel given by

$$\frac{T_{wm} - T_{t1}}{T_{t2} - T_{t1}} = \frac{1}{2}\left[1 + \sqrt{\left(\frac{\pi D_H}{2c_f L}\right)^2 + 1}\right]$$