[lex93] Jet propulsion

When a conventional rocket is launched from rest in a force-free environment, it acquires the speed $v_c = u \ln(m_i/m_f)$, where m_i is the initial mass, m_f the final mass, and u the speed of the exhaust gases relative to the rocket.

(a) Reproduce this result starting from the familiar rocket equation, $m\dot{v} + \dot{m}u = F_{\text{ext}}$, here with zero external force. Keep in mind that this result is limited to nonrelativistic speeds.

(b) Now calculate the speed v_p which a rocket acquires if the difference between its initial rest mass m_i and its final rest mass m_f is converted into radiant energy ejected all in one direction. Start the analysis from the energy and momentum conservation laws.

Solution: