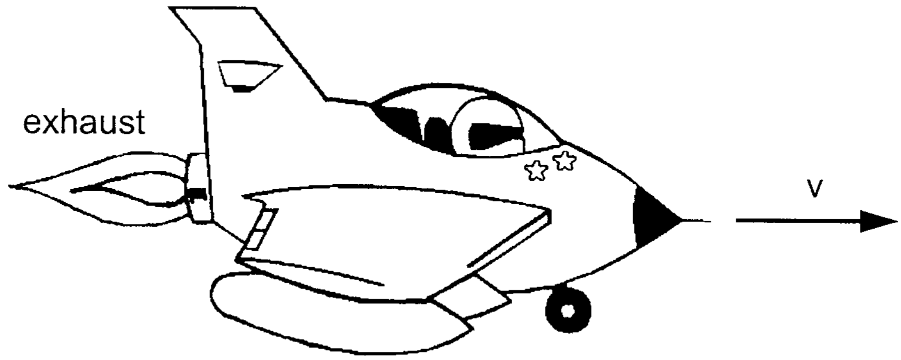
A rocket plane travels through still air in level flight, so that its weight is exactly compensated by the lift from the wings. It expels matter (i.e. loses mass) at a constant rate γ, with the speed of the exhaust relative to the rocket plane being u. The rocket plane experiences a drag force $\vec{F}_D$ from the air, which is proportional to its velocity $\vec{v}$ in the rest frame of the air (and also the ground): $\vec{F}_D = -k\vec{v}$. At time $t = 0$, the rocket plane has mass m_0, and is released from a jumbo jet flying horizontally with speed v_0.



(a) First consider the case where there is no drag on the plane ($k = 0$). In this case, determine the differential equation governing the speed $v(t)$ of the rocket plane. Express your answer entirely in terms of v, t, and the given parameters γ, u, m_0.

(b) Solve your equation to obtain $v(t)$ in the no-drag case.

(c) Now consider the case where there is appreciable drag on the plane: $k > 0$. Determine a new differential equation governing the speed $v(t)$ of the rocket plane in this case. Express your answer entirely in terms of v, t, and the given parameters γ, u, m_0, k.

(d) Solve your equation to obtain $v(t)$ in the case of appreciable drag.

(e) For the case where $k > 0$, determine the general relationship among the parameters that permits the rocket plane to move at constant speed.