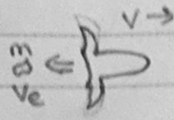
Rocket Science

Conservation of linear momentum



$\vec{P}_i = \vec{P}_f$

$(M+\Delta m)v = M(v+\Delta v) + \Delta m(v - v_e)$

For time Δt - fire the rocket

v_e = exhaust gas speed

$v - v_e$

$M\Delta v = v_e \Delta m$

$M dv = v_e dm$

$-\frac{dM}{dt} v_e = m\frac{dv}{dt}$ ma = force (thrust)

$\boxed{F = -Rv_e}$

← fuel consumption rate

$dv = -v_e \frac{dM}{M}$

$\int_{v_i}^{v_f} dv = -v_e \int_{v_i}^{v_f} \frac{dM}{M} \Rightarrow \boxed{v_f - v_i = -v_e \ln\left(\frac{M_i}{M_f}\right)}$

a. Thrust $= Rv_e$

$= 480(3.27\times10^3) = 1.57\times10^6$ N

b. $R_t = 480(250)$ = fuel burned

$M = M_0 - Rt$

$= 2.55\times10^5 - R_t = 1.35\times10^5$ kg

c. $v_f = v_e \ln\left(\frac{M_i}{M_f}\right)$

$= 3.27\times10^3 \ln\left(2.55\times10^5 / 1.35\times10^5\right) = 2.08\times10^3$ m/s

a. $F = Rv_e$

$mg = 6100(9.8) = R(1200)$

$R = 49.8$ kg/s

b. $Mg + Ma = Rv_e$

$6100(9.8+21) = R(1200)$

$R = 156.6$ kg/s