Q.1

$M_e = 10^5 kg.$

$\varepsilon = 0.06.$ $I_{SP} = 400s$ $\Rightarrow$ $u_{eq} = (I_{SP}) g_e = 3920 m/s.$

$\Delta u = u_b - u_0^0 = (2) u_{eq} \ln R - g t_b$

$\Rightarrow$ $11.2 \times 1000 = (2)(3920) \ln R - 2000$

$\therefore \boxed{R = 5.384}$

$\rightarrow$ $\dfrac{1 + \lambda}{\varepsilon + \lambda} = R$

$1 + \lambda = (5.384)(\varepsilon) + (5.384)\lambda$ $\varepsilon = 0.06$
        $R = 5.384$

$\therefore \boxed{\lambda = 0.154}$

$\rightarrow$ $\lambda_1 = \lambda_2 = 0.154$

$0.154 = \dfrac{M_e}{M_{02} - M_e} = \dfrac{M_{02}}{M_{01} - M_{02}}$

$M_e = 10^5 kg.$

$\therefore \boxed{M_{02} = 7.49 \times 10^5 kg.}$

$0.154 = \dfrac{7.49 \times 10^5}{M_{01} - 7.49 \times 10^5}$

$\boxed{\therefore M_{01} = 56.15 \times 10^5 kg.}$

$\rightarrow$ $M = M_0 \left[1 - \dfrac{t}{t_b}\left(1 - \dfrac{1}{R}\right)\right]$

$du = u_{eq} \ln R - gt$ $\left(R = \dfrac{M_0}{M}\right)$

on differentiating

$\Rightarrow$ $\left.\dfrac{du}{dt}\right|_{t=0} = u_{eq}\left(1 - \dfrac{1}{R}\right)\dfrac{1}{t_b} - g_0$

$0.2 g = u_{eq}\left(1 - \dfrac{1}{R}\right)\dfrac{1}{t_b} - g_0.$

$11.76 = (3920)\left(1 - \dfrac{1}{5.384}\right)\dfrac{1}{t_b}$ $\therefore \boxed{t_{b_1} = 271.42 s}$