This problem is of energy management.

For a given radius R, the spacecraft speed is $v = \sqrt{\frac{\mu}{R}}$ and the reduced energy is $E = \frac{-\mu}{2R}$

The reduced power that goes into the spacecraft total energy is $P_{in} = \frac{\vec{F}.\vec{v}}{m} = \frac{FV}{m}$ if the nozzle is oriented right (opposite to the speed vector).

So: $P_{in} = \frac{F}{m}\sqrt{\frac{\mu}{R}}$

so: $\frac{dE}{dt} = \frac{F}{m}\sqrt{\frac{\mu}{R}} = \frac{F}{m}\sqrt{-2E}$ since $E = \frac{-\mu}{2R}$

so $\frac{dE}{dt} = \frac{F}{m}\sqrt{-2E}$ or $\frac{dE}{\sqrt{-2E}} = \frac{F}{m}$

integrating: $-\left[\sqrt{-2E} - \sqrt{-2E_0}\right] = \frac{F}{m}(t - t_0)$

$t = t_0 \Rightarrow E = \frac{-\mu}{2R_0}$

at t_{escape}, $E = 0$

So: $\sqrt{\frac{\mu}{R_0}} = \frac{F}{m}(t - t_0)$

or: $\boxed{t = t_0 + \frac{m}{F}\sqrt{\frac{\mu}{R_0}}}$