

45. We use Eq. 9-43 and simplify with $v_f - v_i = \Delta v$, and $v_{\text{rel}} = u$.

$$v_f - v_i = v_{\text{rel}} \ln \frac{M_i}{M_f} \implies \frac{M_f}{M_i} = e^{-\Delta v/u}$$

If $\Delta v = 2.2 \text{ m/s}$ and $u = 1000 \text{ m/s}$, we obtain $\frac{M_i - M_f}{M_i} = 1 - e^{-0.0022} \approx 0.0022$.