67. (a) The drawings in the Figure (especially pictures (b) and (c)) show this geometric relationship very clearly. But we can work out the details, if need be. If ℓ is the length we are to compute (that of the still moving upper section) and ℓ' is the length of the lower (motionless) section, then clearly $\ell + \ell' = L$. Also, (as is especially easy to see in picture (c)) $x + \ell$ must equal ℓ'. These two equations, then, lead to the conclusion $\ell = \frac{1}{2}(L - x)$.

(b) The mass of the still moving upper section is

$$m = \rho\ell = \frac{\rho}{2}(L - x) \ .$$

(c) The assumptions stated in the problem lead to

$$\frac{1}{2}(\rho L + m_f)\, v_0^2 = \frac{1}{2}\left(\frac{\rho}{2}(L - x) + m_f\right) v^2$$

which yields the speed of the still moving upper section:

$$v = v_0\sqrt{\frac{\rho L + m_f}{\rho(L - x)/2 + m_f}} \ .$$

(d) As x approaches L, we obtain

$$v_f = v_0\sqrt{\frac{\rho L + m_f}{m_f}} = (6.0)\sqrt{\frac{(1.3)(20) + 0.8}{0.8}}$$

which yields $v_f = 35$ m/s.