12. (a) From Eqs. 35-3 and 35-4, we obtain $i = pf/(p-f) = pr/(2p-r)$. Differentiating both sides with respect to time and using $v_O = -dp/dt$, we find

$$v_I = \frac{di}{dt} = \frac{d}{dt}\left(\frac{pr}{2p-r}\right) = \frac{-rv_O(2p-r)+2v_Opr}{(2p-r)^2} = \left(\frac{r}{2p-r}\right)^2 v_O \ .$$

(b) If $p = 30\,\text{cm}$, we obtain

$$v_I = \left[\frac{15\,\text{cm}}{2(30\,\text{cm})-15\,\text{cm}}\right]^2 (5.0\,\text{cm/s}) = 0.56\ \text{cm/s} \ .$$

(c) If $p = 8.0\,\text{cm}$, we obtain

$$v_I = \left[\frac{15\,\text{cm}}{2(8.0\,\text{cm})-15\,\text{cm}}\right]^2 (5.0\,\text{cm/s}) = 1.1\times 10^3\ \text{cm/s} \ .$$

(d) If $p = 1.0\,\text{cm}$, we obtain

$$v_I = \left[\frac{15\,\text{cm}}{2(1.0\,\text{cm})-15\,\text{cm}}\right]^2 (5.0\,\text{cm/s}) = 6.7\ \text{cm/s} \ .$$