

9. (a) In the region of the smaller loop the magnetic field produced by the larger loop may be taken to be uniform and equal to its value at the center of the smaller loop, on the axis. Eq. 30-29, with  $z = x$  (taken to be much greater than  $R$ ), gives

$$\vec{B} = \frac{\mu_0 i R^2}{2x^3} \hat{i}$$

where the  $+x$  direction is upward in Fig. 31-36. The magnetic flux through the smaller loop is, to a good approximation, the product of this field and the area ( $\pi r^2$ ) of the smaller loop:

$$\Phi_B = \frac{\pi \mu_0 i r^2 R^2}{2x^3} .$$

- (b) The emf is given by Faraday's law:

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\left(\frac{\pi \mu_0 i r^2 R^2}{2}\right) \frac{d}{dt} \left(\frac{1}{x^3}\right) = -\left(\frac{\pi \mu_0 i r^2 R^2}{2}\right) \left(-\frac{3}{x^4} \frac{dx}{dt}\right) = \frac{3\pi \mu_0 i r^2 R^2 v}{2x^4} .$$

- (c) As the smaller loop moves upward, the flux through it decreases, and we have situation like that shown in Fig. 31-5(b). The induced current will be directed so as to produce a magnetic field that is upward through the smaller loop, in the same direction as the field of the larger loop. It will be counterclockwise as viewed from above, in the same direction as the current in the larger loop.