33.35. Model: Assume that the magnetic field of coil 1 passes through coil 2 and that we can use the magnetic field of a solenoid for coil 1.

Visualize: Please refer to Figure P33.35. The field of coil 1 produces flux in coil 2. The changing current in coil 1 gives a changing flux in coil 2 and a corresponding induced emf and current in coil 2.

Solve: From 0 s to 0.1 s and 0.3 s to 0.4 s the current in coil 1 is constant so the current in coil 2 is zero. From 0.1 s to 0 s, the induced current from the induced emf is given by Faraday's law. The current in coil 2 is

$$I_2 = \frac{\mathcal{E}_2}{R} = \frac{1}{R}N_2\left|\frac{d\Phi_2}{dt}\right| = \frac{1}{R}N_2A_2\left|\frac{dB_1}{dt}\right| = \frac{1}{R}N_2\pi r_2^2\left|\frac{d}{dt}\left(\frac{\mu_0 N_1 I_1}{l_1}\right)\right| = \frac{N_2\pi r_2^2\mu_0 N_1}{Rl_1}\left|\frac{dI_1}{dt}\right|$$

$$= \frac{20\pi(0.010\text{ m})^2(4\pi\times10^{-7}\text{ T m / A})(20)}{(2\Omega)(0.020\text{ m})}|20\text{ A / s}| = 7.95\times10^{-5}\text{ A} = 79\mu\text{A}$$

We used the facts that the field of coil 1 is constant inside the loops of coil 2 and the flux is confined to the area $A_2 = \pi r_2^2$ of coil 2. Also, we used $l_1 = N_1 d = 20(1.0\text{ mm}) = 0.020\text{ m}$ and $|dI/dt|$ = 20 A/s. From 0.1 s to 0.2 s the current in coil 1 is initially negative so the field is initially to the right and the flux is decreasing. The induced current will *oppose this change* and will therefore produce a field to the right. This requires an induced current in coil 2 that comes out of the page at the top of the loops so it is negative. From 0.2 s to 0.3 s the current in coil 1 is positive so the field is to the left and the flux is increasing. The induced current will *oppose this change* and will therefore produce a field to the right. Again, this is a negative current.