How To Find the Induced EMF in a Loop Using Faraday's Law and Lenz's Rule

Actually, problems involving induction tend not to be so amenable to a simple "how-to": in general, they vary a lot in terms of what you are asked to find for the final answer, and in terms how you are expected to use the induced EMF or current. *However*, there are some systematic steps you can follow for finding the induced EMF in a loop.

1. Identify the loop. Remember that you need a closed loop for a current to flow.

2. Find the magnetic flux Φ_B *through the loop*. The flux $\Phi_B = \vec{B} \cdot \vec{A}$ depends on both the magnetic field and the area of the loop. Note that either $\vec{B}$ *or* $\vec{A}$ (or their relative orientation) could be changing in time (or, in principle, both, but typically it will be one or the other in problems you will see.) Consider how things are changing in time.

3. Calculate the time derivative of the flux, $d\Phi_B/dt$. The magnitude of the induced EMF, $|\varepsilon_{\text{ind}}|$ is equal to $|d\Phi_B/dt|$. If you need to find a current, you can frequently find it using Ohm's Law, $I_{\text{ind}} = \varepsilon_{\text{ind}}/R$, where R is the resistance of the wire.

4. Now find the direction of the induced current (or EMF). This is where Lenz's Rule comes in. The direction of the induced current is such that the induced current makes a magnetic field *opposes the change in flux*. Use the right hand rule to find the direction of magnetic field produced by the induced current.

    - If the flux is *increasing* in some direction, the induced current must make a magnetic field that *decreases* the flux in that direction.
    - If the flux is *decreasing*, the induced current must make a magnetic field that *increases* the flux in that direction.

5. Now, use the current or EMF you have found to answer the question you are asked. Problems tend to differ from one another at this point. For instance, you may be asked about motion vs time. In this case, write down $\Sigma\vec{F} = m\vec{a}$; one of the forces involved is probably a magnetic

force $\vec{F}_m$ due to the induced current in the external magnetic field, $\vec{F} = I\vec{l} \times \vec{B}$, where $\vec{l}$ is the length of a segment wire in the magnetic field. Here you use the first right hand rule to find the force. Solve for what you need (often this will be a differential equation).