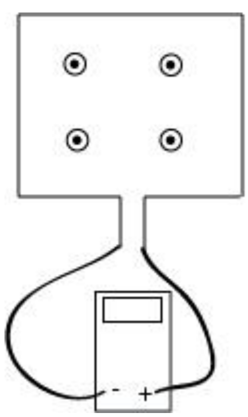
On the sign of the induction voltage.

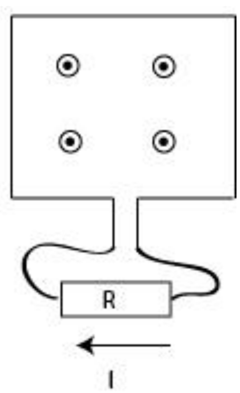
In EMT we studied the Faraday's induction law and found:

$$emf = -\frac{\partial \Phi}{\partial t} \qquad [1]$$

Where Φ is the flux enclosed through the loop. The flux can originate from an external field source or from the current through the loop itself. The minus sign is often referred to as Lenz' law, and shows that the emf opposes the flux change.

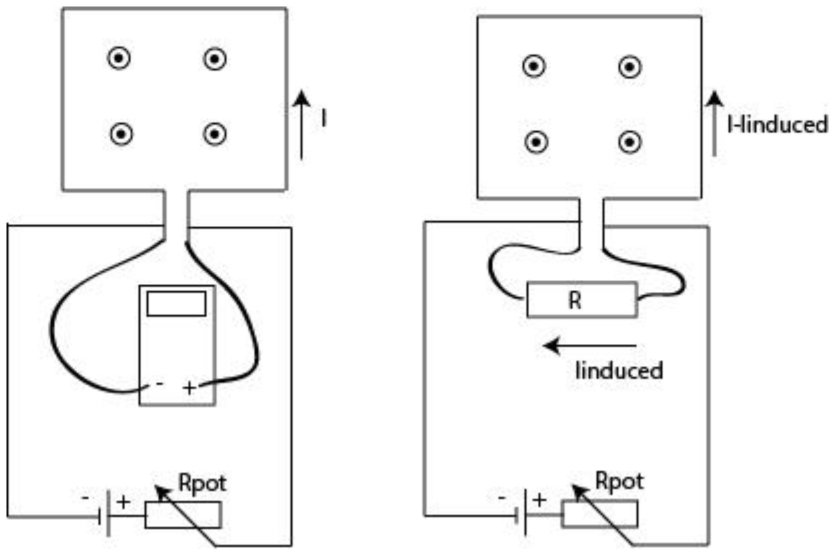
The direction of the induced voltage can be better understood by considering first the effect of an external magnetic field. Consider a loop placed in a magnetic field. Assume that a magnetic field is applied to the loop as sketched in the left figure below. So the field is coming out of the plane of the picture. Now assume that we increase the magnetic field. According to Lenz' law the induced emf will be clock wise, so positive charges are pushed clockwise towards the right bottom wire. So if a digital multimeter is connected between both wires a voltage is measured and one concludes that the right wire is at higher electric potential than the left wire. If a resistor is connected to both wires the current will flow through the resistor as sketched in the figure on the right.





It is not necessary to have an external magnetic field. The change of the magnetic field generated by the current through the coil will also induce an emf of the same sign. So consider the loop is connected to a battery in series with a variable resistor, R_{pot}. If we assume a constant current and if we assume that the resistance of the wire is negligible, no voltage is measured by the digital multimeter. Decreasing the resistor R_{pot} though will increase the current through the loop and will create an emf of the same sign as in the example provided above.

Assume that we replace the multimeter by a resistor R as shown in the figure below on the left. There will be no current induced in the coil if the current through the circuit is constant, so I induced is zero and the current through the loop is $I\text{-}I_{induced}=I$. If the variable resistor is slowly decreased, the current through the loop will increase, resulting in a larger flux forcing an induction current through the resistor R as shown in the figure below on the right. In the coil this induction current will counteract the increase of current through the coil.



Above discussion shows that an increasing current through the inductor from right to the left will result in the right side of the coil to be at a higher potential than the left side. So if we define the voltage across the inductor and the current through the inductor according to the figure below, the I-V relation of an inductor is given by:

$$V = L\frac{\partial I}{\partial t}$$

When analyzing electronic circuits one normally uses the sign definition defined by the figure below. Notice that this sign definition is similar of the sign definition of a resistor, i.e. the voltage drop is positive in the direction of the current, similar to a resistor. This is the convention often used by electrical engineers.