An electrical circuit consists of impressed voltage (=battery) giving voltage \( E(t) \), a resistor, a capacitor and an inductor. [See Fig. 1 below.]

An electrical current is a flow of charge electrons along the conductor. They encounter some resistance from the material of the conductor. If the voltage (=difference of potential) between ends of a conductor is \( U_R \), and a current is \( I \), then the resistance is defined as \( R = U_R/I \) (Ohm's law). So \( U_R = RI \). Usually, to control resistance, they make special elements called *resistors* with given resistance.

A *capacitor* is usually two parallel plates, one of them is charged positively, the other - negatively. If \( Q \) is the charge on the positive plate, then \(-Q\) is the charge on the negative plate. The capacitor has a characteristic which is called *capacity*: \( C \). And if \( U_C \) is the voltage on the capacitor, then \( U_C = Q/C \).

An *inductor* is a spiral conductor, which creates an electric field, that is, a voltage, when the current changes. So the voltage \( U_L \) is created by \( I' \). In fact, \( U_L = -LI' \), where \( L \) is the *inductance* of the inductor.

The minus sign is because of *Lenz's law*: the new voltage wants to stop the change in current; in other words, this system has negative feedback. This makes sense: indeed, if it were to reinforce this change, if the system had positive feedback, then every slight change in a current would get amplified, and there would be current flowing along any wire.

The original voltage \( E(t) \) produced by the battery plus the induced voltage \(-LI'(t)\) produced by the inductor must be equal to the sum of voltages consumed by the capacitor \( Q/C \) and the resistor \( RI \), so

\[
E(t) - LI'(t) = RI(t) + \frac{Q(t)}{C}.
\]

But the change of \( Q \) is \( I \): \( Q' = I \), because the current is nothing else than the flow of charges. Therefore,

\[
\frac{1}{C}Q(t) + RQ'(t) + LQ''(t) = E(t)
\]

The same theory of second-order differential equations applies to this situation as well as to mechanical vibrations: steady-state solutions, resonance, etc. This is the power of mathematics: we do not need to develop anything new!