The current-voltage relationship of the capacitor is obtained by differentiating $Q = CV$ to get

$$I = \frac{dQ}{dt} = C\frac{dV_C}{dt}.$$

Unlike a resistor, current in a capacitor is proportional to the derivative of voltage rather than voltage itself. Alternatively, it can be said that the voltage on a capacitor is proportional to the time integral of the influx current.

$$V_C = \int Idt$$

A typical example of a capacitor circuit is shown in *Figure 2.5*, where the capacitor is connected in series with a resistor, a switch, and an ideal voltage source. Initially, for $t < 0$, the switch is open and the voltage on the capacitor is zero. The switch closes at $t = 0$, the voltage drop across the resistor is $V_{in} - V_C$, and charges flows onto the capacitor at the rate of $(V_{in} - V_C)/R$. As voltage builds on the capacitor, the corresponding voltage on the resistor is therefore decreased. The reduction in voltage leads to a reduction of the current through the circuit loop and slows the charging process. The exact behavior of voltage across the capacitor can be found by solving the first order differential equation,

$$C\frac{dV_C}{dt} = \frac{V_S - V_C}{R}.$$

The voltage across the capacitor behaves as an exponential function of time, which is shown in Figure ###. The term *RC*, is known as the time constant of the exponential function, and is often simply denoted as τ.

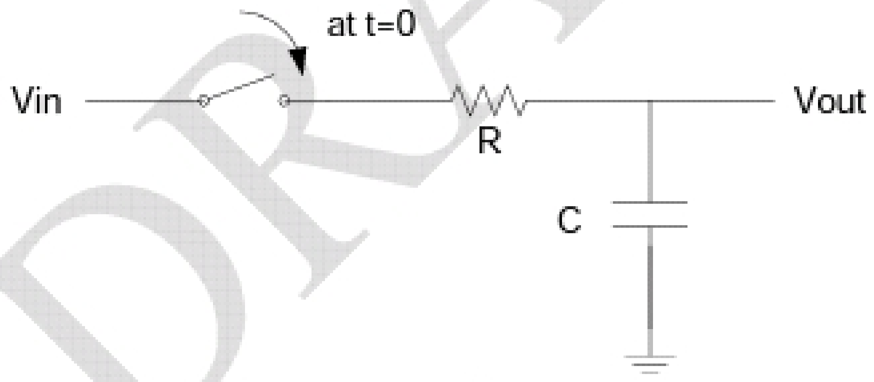

Figure 2.5: Simple RC circuit

(### insert plot of RC response here ###)
Figure ###: Voltage output for the RC circuit as a function of time

2.3 Inductor

An inductor is a device that stores energy in the form of current. The most common form of inductors is a wire wound into a coil. The magnetic field generated by the wire creates a counter-acting electric field which impedes changes to the current. This effect is known as Lenz's law and is stated mathematically as

$$V_L = -L\frac{dI}{dt}.$$

The unit of inductance is a Henry (H) and common inductors range nanohenries (nH) to microhenries (μH).

In the hydrodynamic analogy of electronic circuits, an inductor can be thought of as a fluid channel pushing a flywheel as shown in *Figure 2.6*. When the fluid velocity