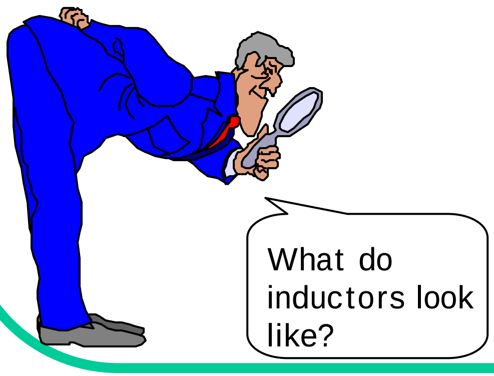
# Inductors

- An inductor is just a coil of wire and its circuit symbol is as shown
- The voltage across it varies as

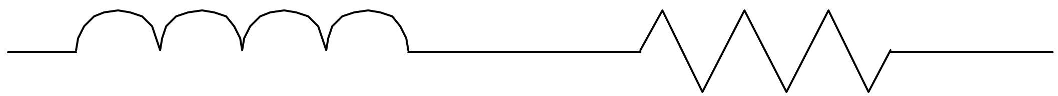
$$V = L\frac{dI}{dt}$$

- Thus, if the current is constant, the voltage across an ideal inductor is zero (as expected since it is just a coil of wire)
- Real inductors will always exhibit some resistance, unless we use superconducting wire (need very low temperatures)




# Ideal Inductors

- Real inductors always exhibit significant resistance unlike capacitors which can be manufactured with negligible resistance.
- If we wish to represent a real inductor, we just model it by a *lumped circuit model* consisting of an ideal *lossless* inductor in series with a resistor.

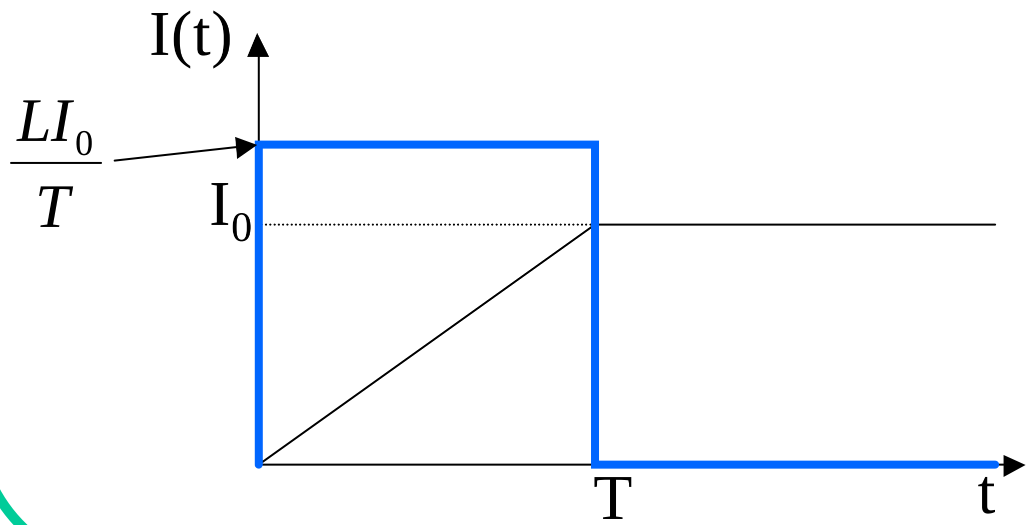


- Lumped circuit models work well in most practical applications until you get up to microwave frequencies and beyond

# Example

- Use $$V = L\frac{dI}{dt}$$

  to determine the voltage a cross an inductor L when supplied with the current ramp shown below

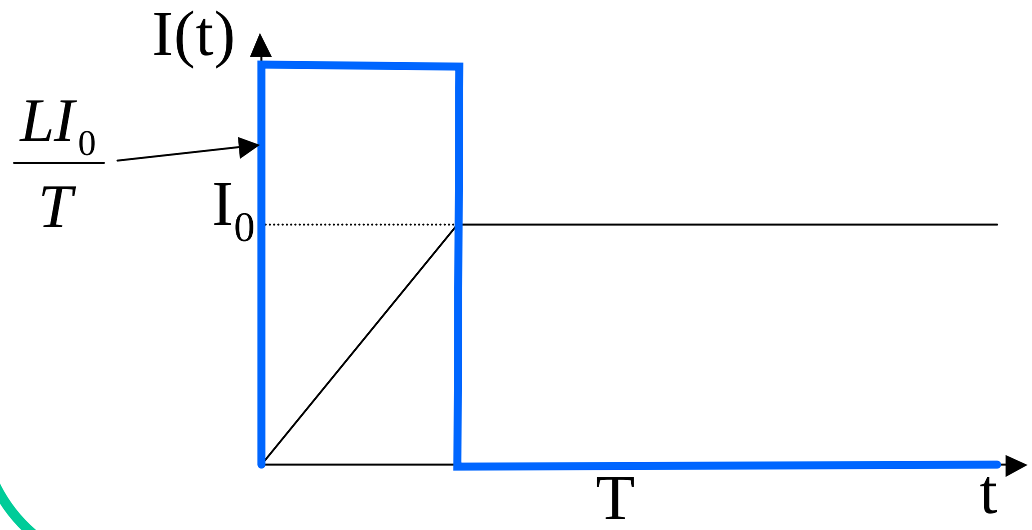



$$V = L\frac{dI}{dt}$$

$$= \begin{cases} 0, & t < 0 \\ \frac{LI_0}{T}, & 0 \le t \le T \\ 0, & t > T \end{cases}$$

# Step Response

- As we increase the slope of the current ramp, the voltage increases
- Towards the limit, as the ramp approaches a step function, T approaches 0, and the voltage approaches infinity




$$V = L\frac{dI}{dt}$$

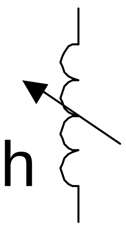
$$= \begin{cases} 0, & t < 0 \\ \frac{LI_0}{T}, & 0 \le t \le T \\ 0, & t > T \end{cases}$$

# Comments

- The fact that instantaneous changes in the current would result in infinite voltage spikes indicates that the current in an inductance cannot change instantaneously.
- In the water model, one could say that water flowing in a pipe cannot change it's flow rate instantaneously.
- If we attempt to instantaneously stop flowing water in household plumbing, we often hear water hammer. Hammer can burst pipes due to the high water pressures (cf high voltages) induced by stopping the flow.
- Although this argument seems reasonable, inductors actually store their energy in a magnetic field rather than kinetic energy, so the water model is quite inadequate to describe many effects and we will therefore abandon this approach.

# Magnetic Field

- A steady current through a coil causes a steady magnetic field to be produced around the coil which cuts through the wire as it does so.
- This field stores energy which produces a voltage which tends to oppose changes in current.
- The effect can be magnified by winding the coil on a magnetic core. This is because the core increases the *magnetic flux* that cuts through the coil.
- Thus adding a core increases the inductance.
- Sometimes the position of the core is adjustable with a screw thread. This gives you a variable inductor.



# Magnetic Flux