PC200 Lectures

Terry Sturtevant

Wilfrid Laurier University

June 4, 2009

Capacitor

- an electronic device which consists of two conductive plates separated by an insulator

Capacitor

- an electronic device which consists of two conductive plates separated by an insulator
- value, capacitance, is proportional to the surface area of the plates and inversely proportional to the distance between the plates

Capacitor

- an electronic device which consists of two conductive plates separated by an insulator
- value, capacitance, is proportional to the surface area of the plates and inversely proportional to the distance between the plates

  measured in Farads

Capacitor

- an electronic device which consists of two conductive plates separated by an insulator
- value, capacitance, is proportional to the surface area of the plates and inversely proportional to the distance between the plates

  measured in Farads

  Farads are *big*

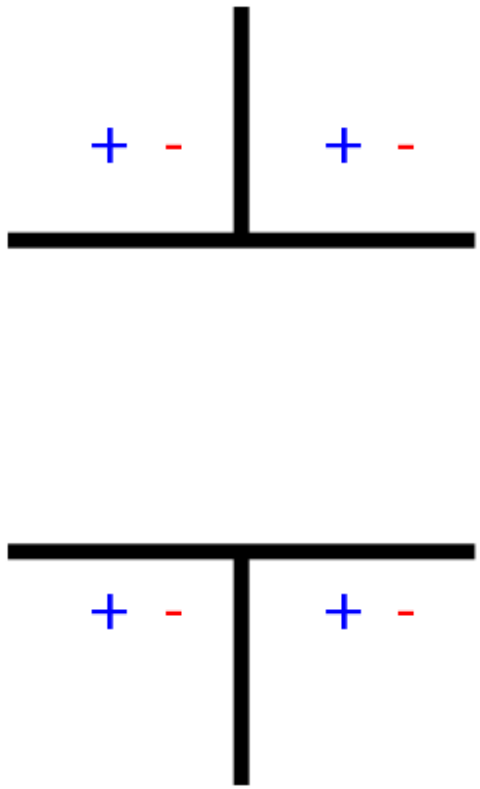
Capacitor

- an electronic device which consists of two conductive plates separated by an insulator
- value, capacitance, is proportional to the surface area of the plates and inversely proportional to the distance between the plates

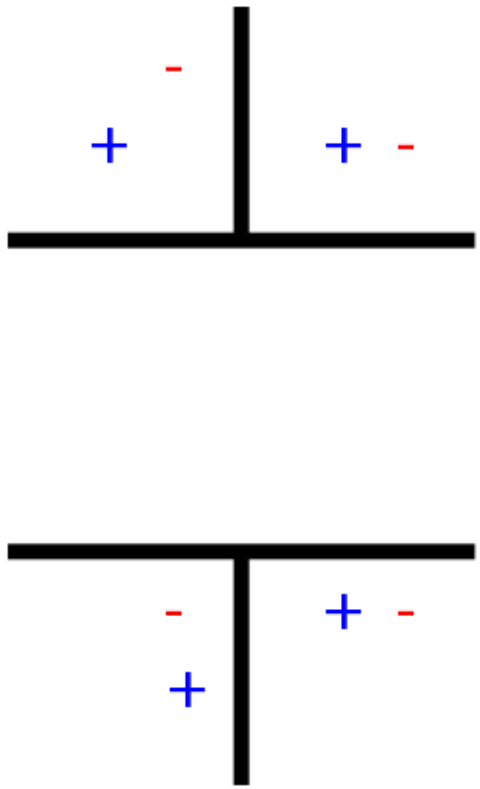
  measured in Farads

  Farads are *big*

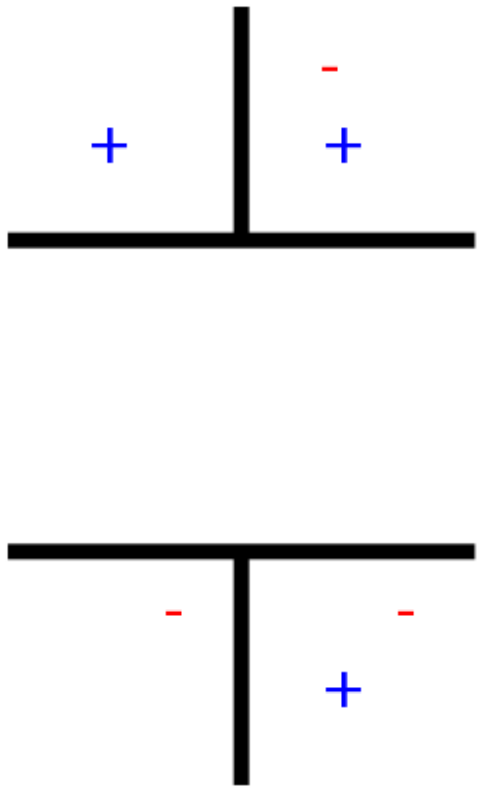
  usually microfarad (μF) or picofarad (pF) values are used



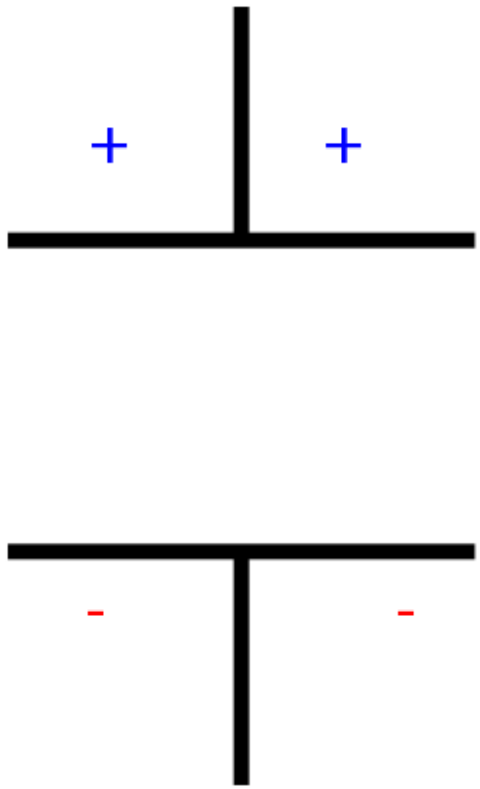
Capacitor uncharged



Capacitor charging; charge on opposite plates is equal and opposite.



Capacitor charging; charge on opposite plates is equal and opposite.



Capacitor charged; no more change

- purpose is to store electrical charge.

- purpose is to store electrical charge.
- current starts large, voltage starts at zero

- purpose is to store electrical charge.
- current starts large, voltage starts at zero

  as charge is stored, voltage increases and current decreases until the voltage equals the applied voltage, when current becomes zero

- A capacitor's voltage may not exceed the maximum for which it is rated. **Big capacitors often have low maximum voltages.**

- A capacitor's voltage may not exceed the maximum for which it is rated. **Big capacitors often have low maximum voltages.**
- Capacitors may retain charge long after power is removed.

- A capacitor's voltage may not exceed the maximum for which it is rated. **Big capacitors often have low maximum voltages.**
- Capacitors may retain charge long after power is removed.
- For safety, large capacitors should be discharged before handling.

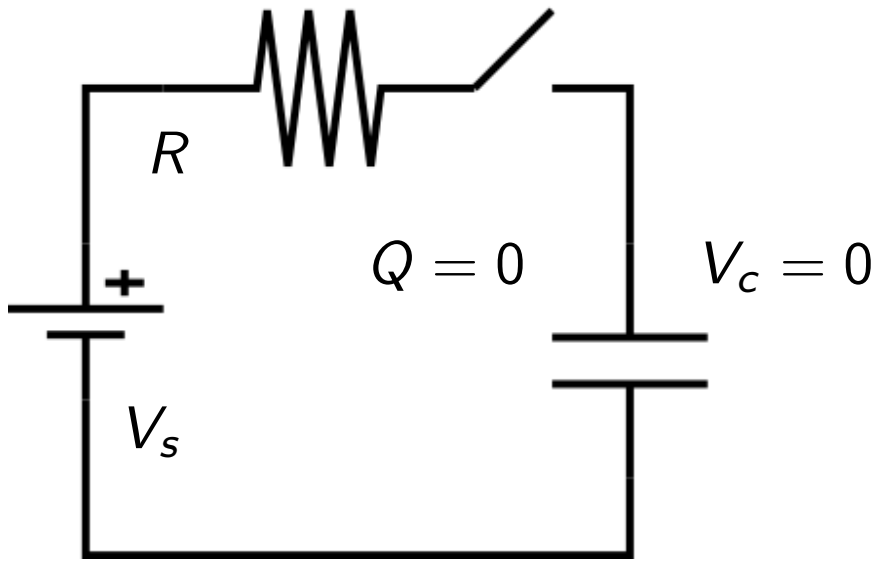
- A capacitor's voltage may not exceed the maximum for which it is rated. **Big capacitors often have low maximum voltages.**
- Capacitors may retain charge long after power is removed.
- For safety, large capacitors should be discharged before handling.

  Place $1k\Omega \rightarrow 1k\Omega$ resistor across the terminals to discharge.

- A capacitor's voltage may not exceed the maximum for which it is rated. **Big capacitors often have low maximum voltages.**
- Capacitors may retain charge long after power is removed.
- For safety, large capacitors should be discharged before handling.

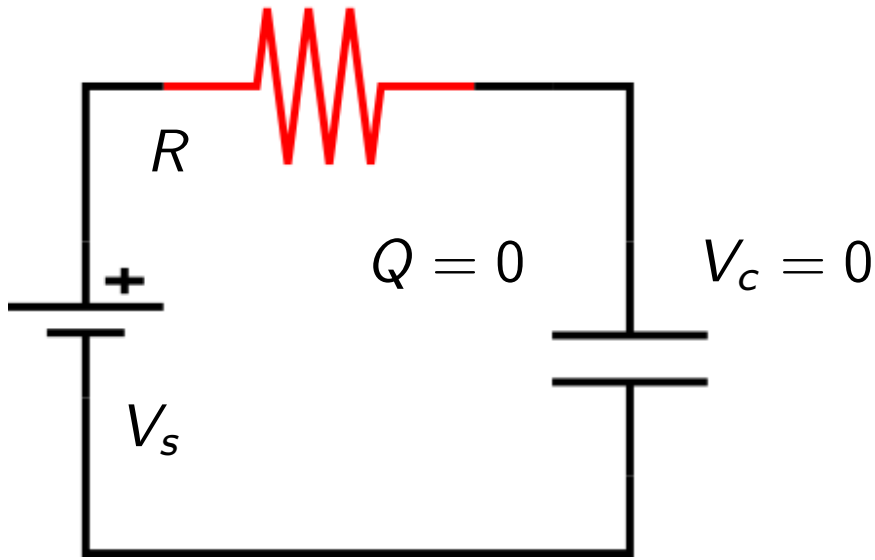
  Place $1k\Omega \rightarrow 1k\Omega$ resistor across the terminals to discharge.
- High voltage capacitors should be stored with terminals shorted.

$$I = 0$$



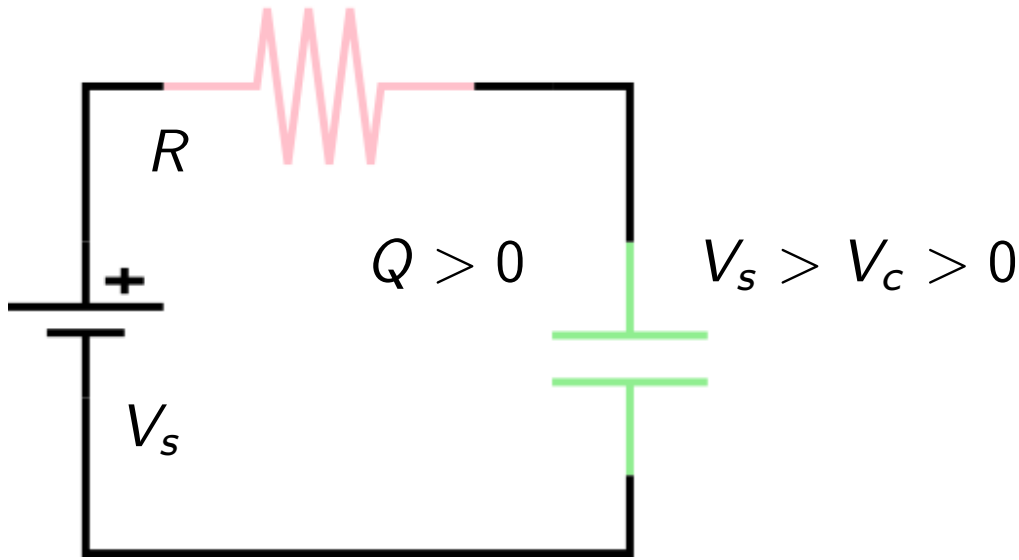
$t = 0$, switch **open**

$$I = V_s/R$$



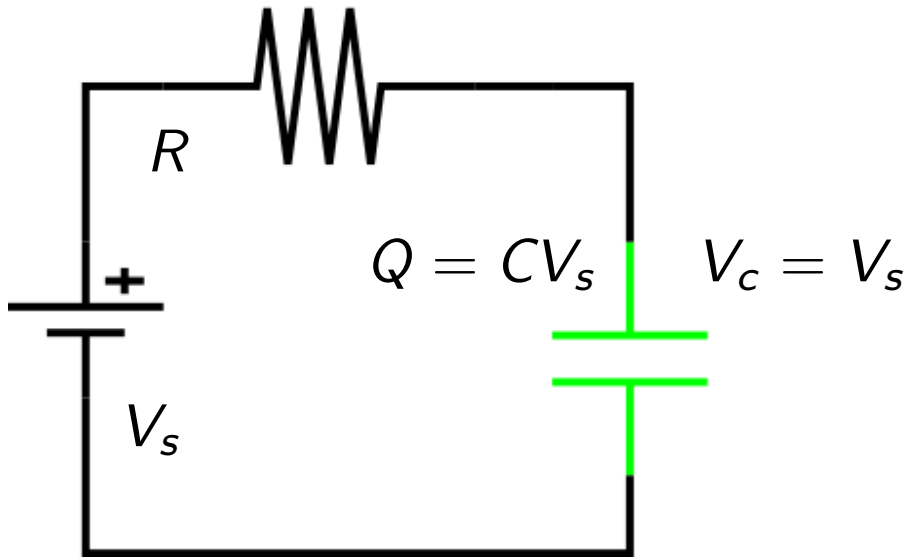
$t = 0$, switch closed

$$I < V_s/R$$



$$t \approx RC$$

$$I = 0$$



$$t >> RC$$

- Some capacitiors are unpolarized (like resistors);

- Some capacitiors are unpolarized (like resistors); i.e. they can be placed either way in a circuit.

- Some capacitiors are unpolarized (like resistors);

  i.e. they can be placed either way in a circuit.
- Other types, (such as "electrolytics"), must be placed in a particular direction

- Some capacitiors are unpolarized (like resistors);

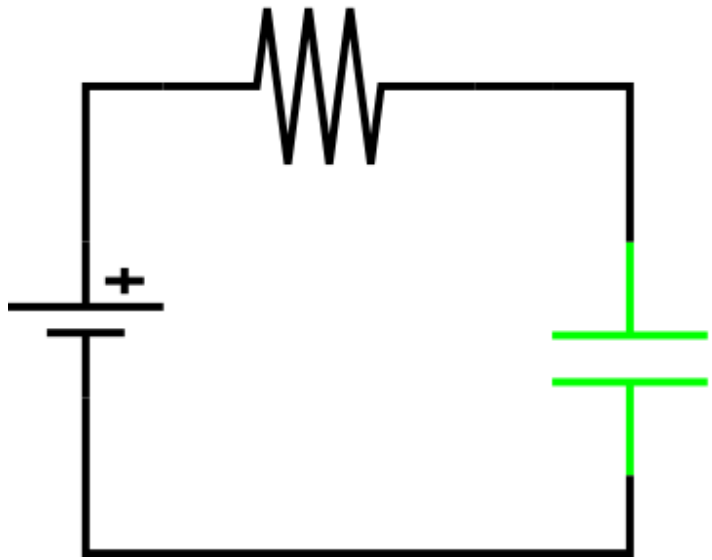
  i.e. they can be placed either way in a circuit.
- Other types, (such as "electrolytics"), must be placed in a particular direction

  (indicated by a "+" sign at one end.)

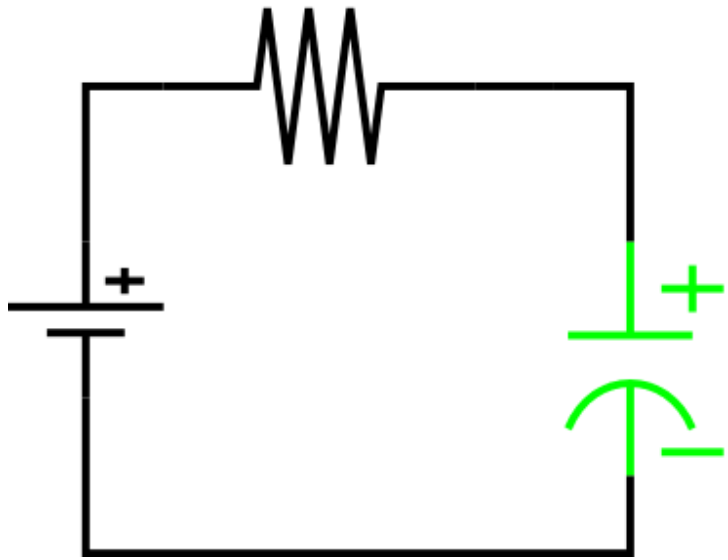
- Some capacitiors are unpolarized (like resistors);

  i.e. they can be placed either way in a circuit.
- Other types, (such as "electrolytics"), must be placed in a particular direction

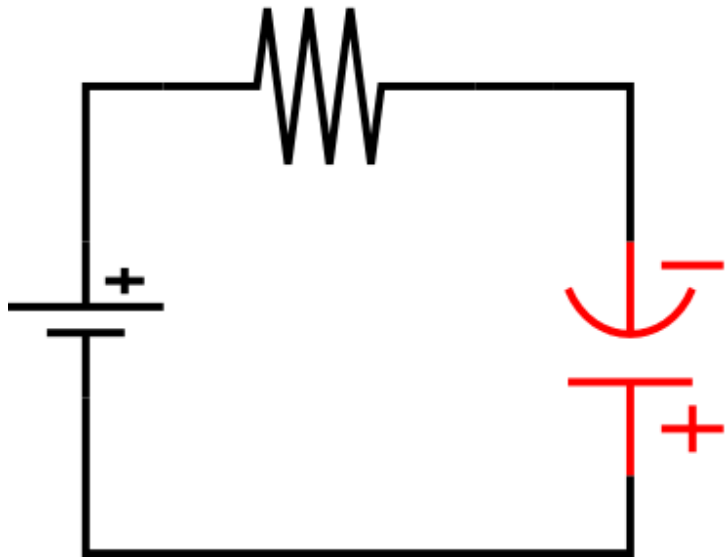
  (indicated by a "+" sign at one end.)
- **Big capacitors ($\gtrsim 1\mu F$) are usually electrolytic.**



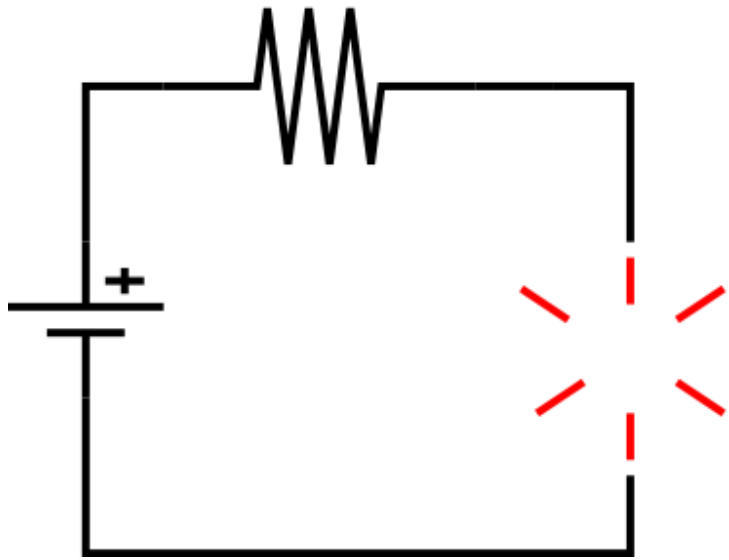
Non-polarized capacitor



Polarized capacitor connected the right way



Polarized capacitor connected the wrong way



Don't do this!!!

Diode

- an electronic device which passes current in one direction only

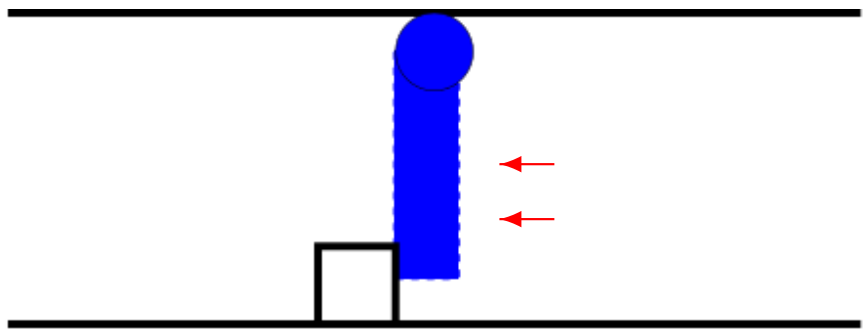
Diode

- an electronic device which passes current in one direction only
- diode starts to allow current in the forward direction when the voltage reaches around 0.6V

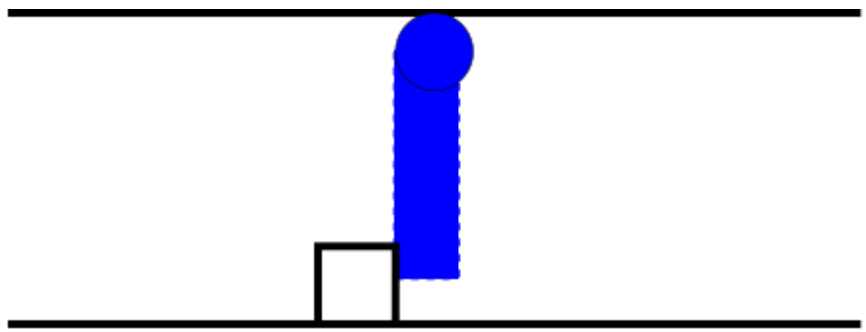
Diode

- an electronic device which passes current in one direction only
- diode starts to allow current in the forward direction when the voltage reaches around 0.6V
- If the voltage gets high enough in the reverse direction, the diode will conduct; *"reverse breakdown voltage"*

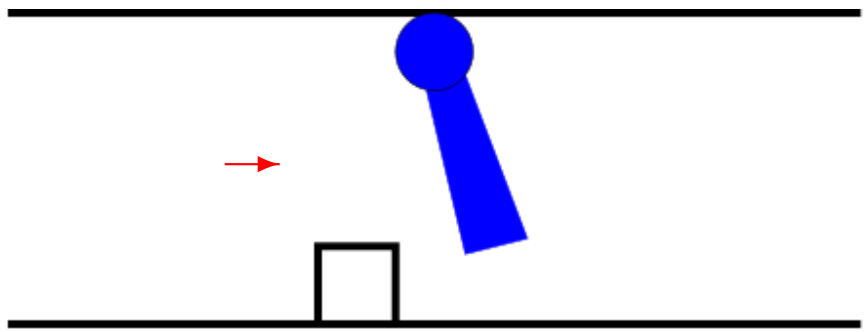
Negative pressure; no flow possible



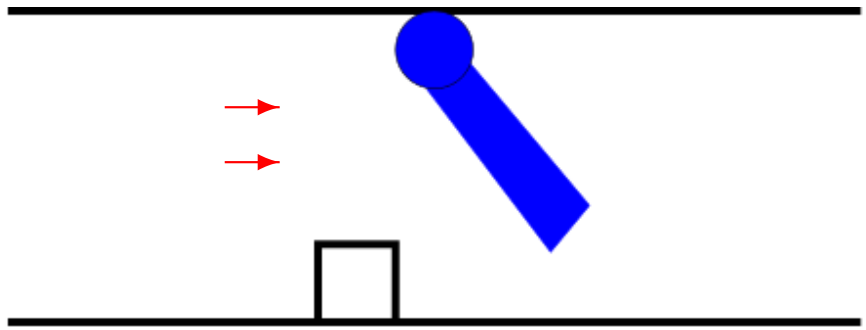
No pressure; resistance to flow is large



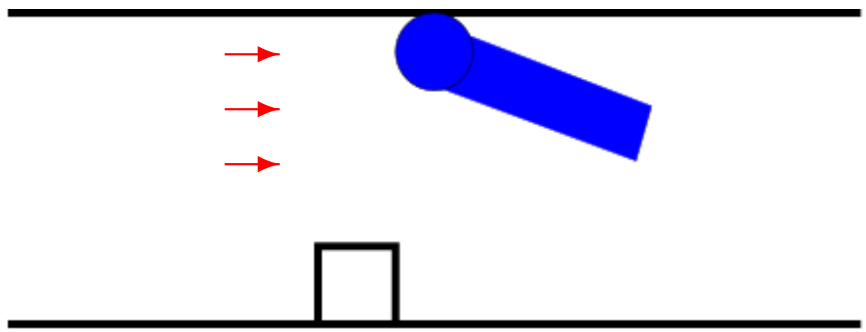
Small pressure; resistance to flow decreases



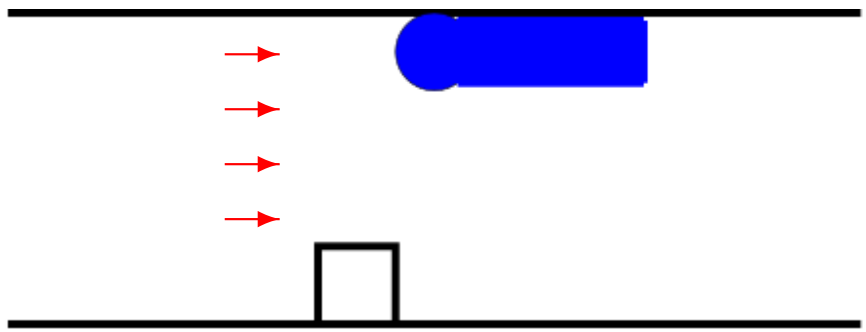
Medium pressure; resistance to flow still decreasing

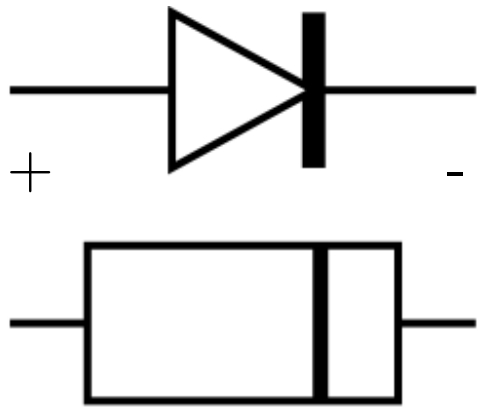


High pressure; resistance to flow small

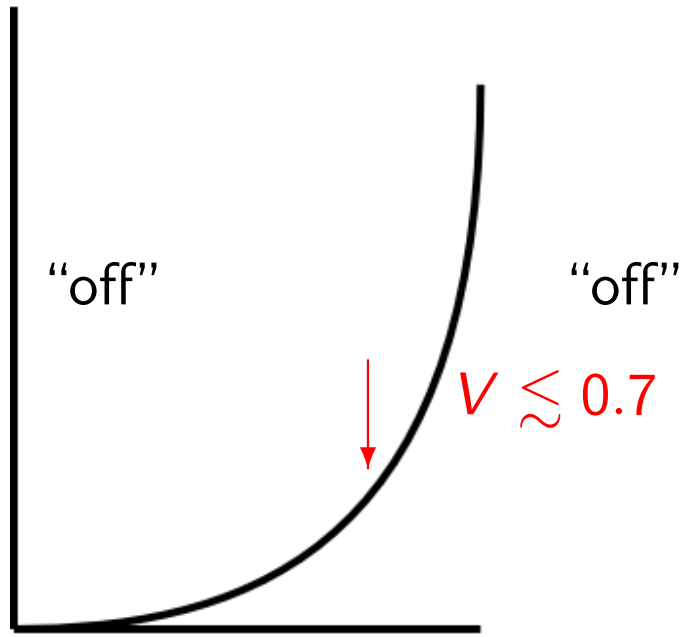


Very high pressure; resistance almost zero

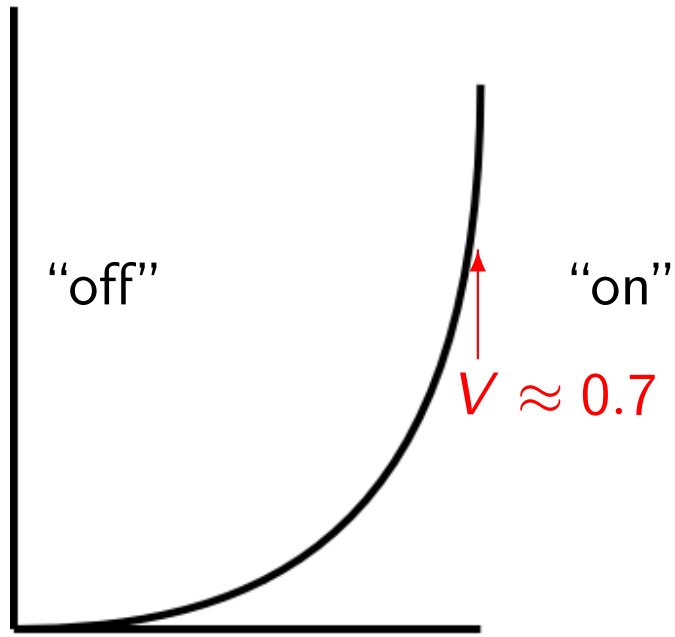




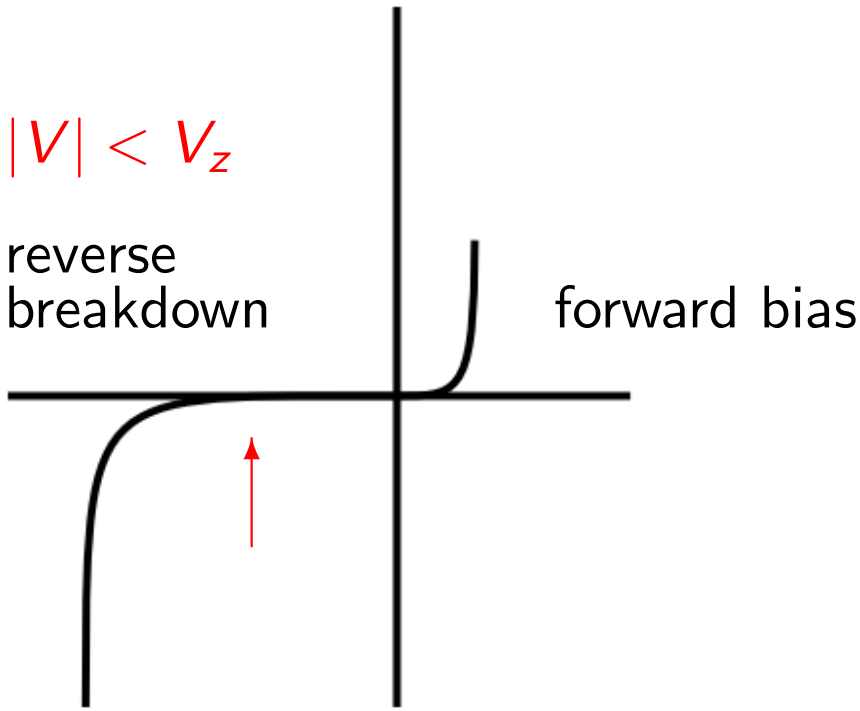
Diode symbol and physical appearance



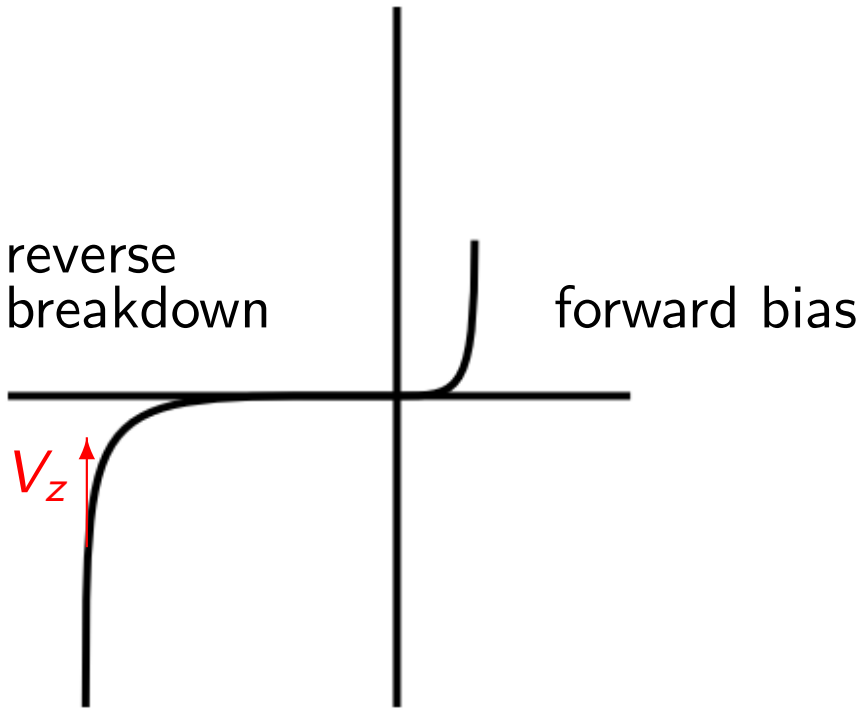
I small; changes slowly



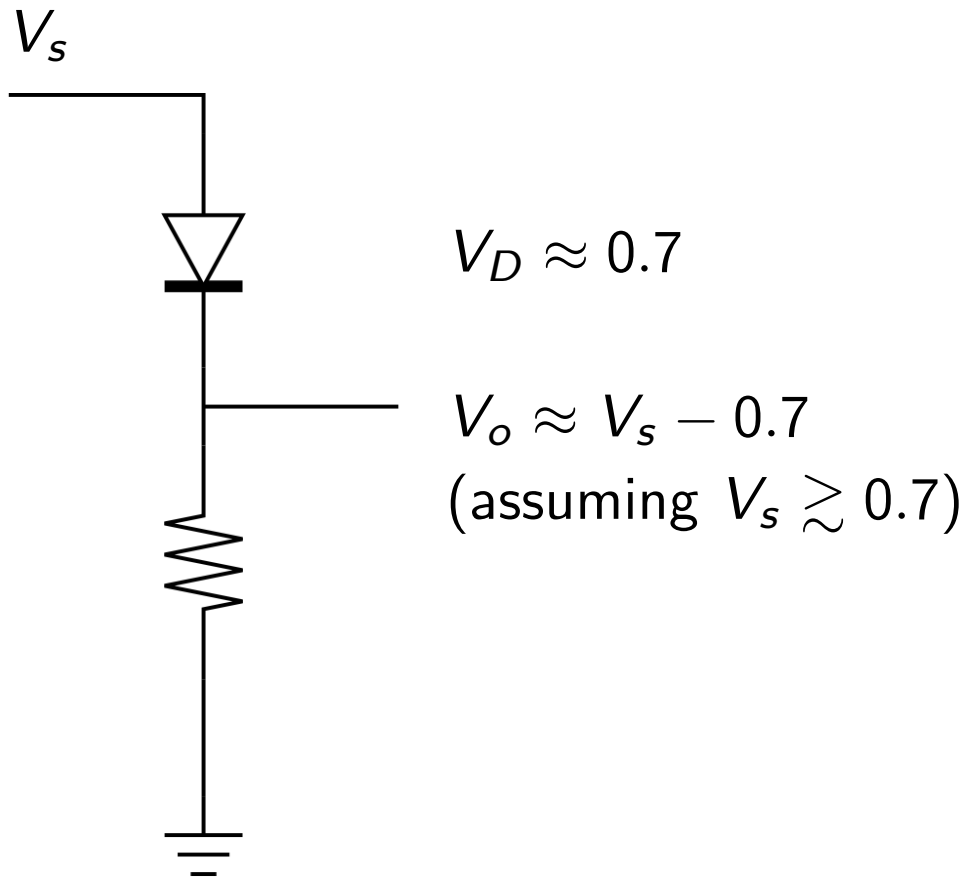
I large; almost independent of V



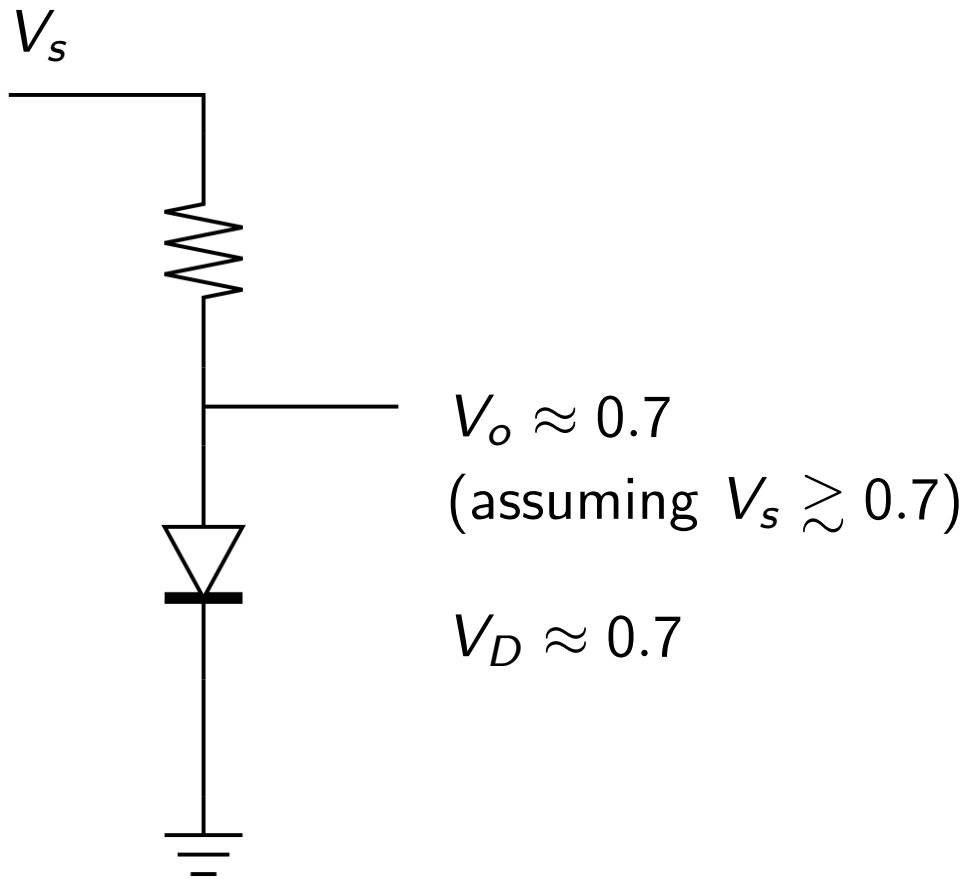
I small; changes slowly



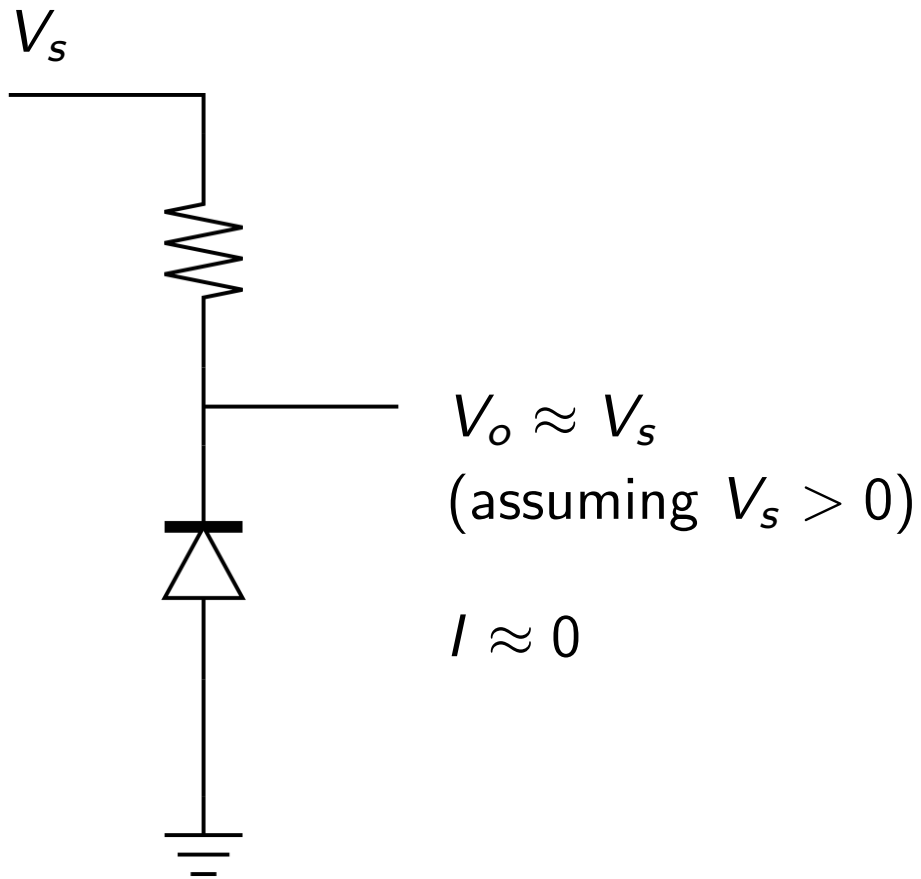
I large; almost independent of V



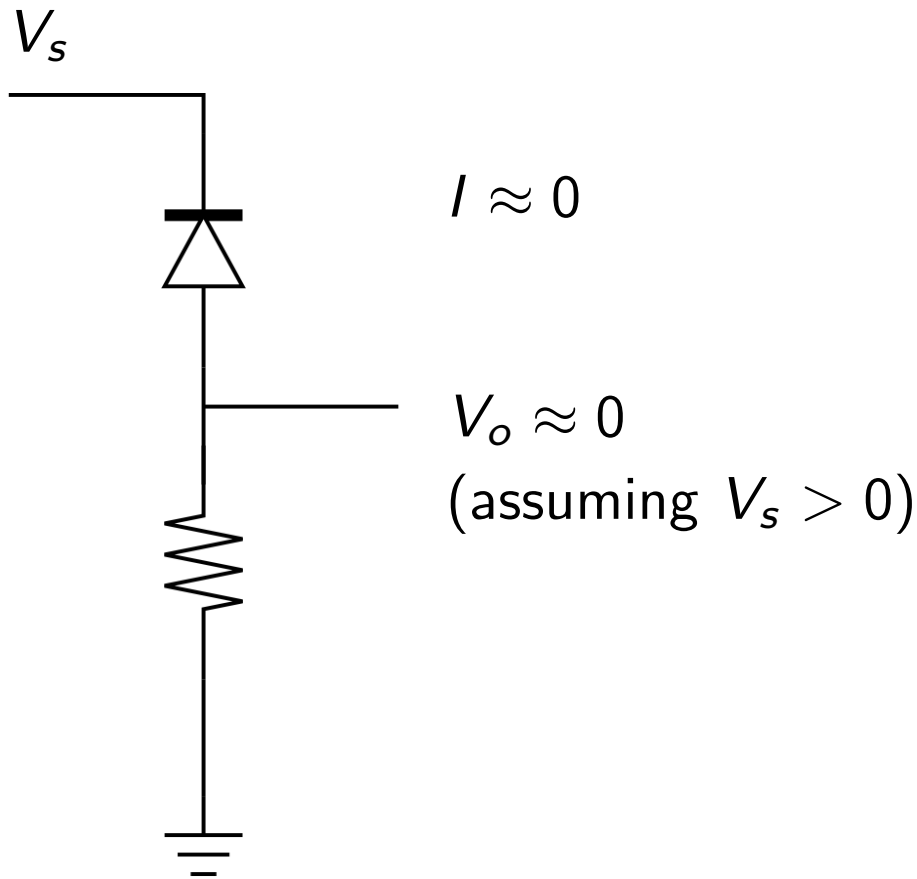
Forward biased diode in a voltage divider



Forward biased diode in a voltage divider

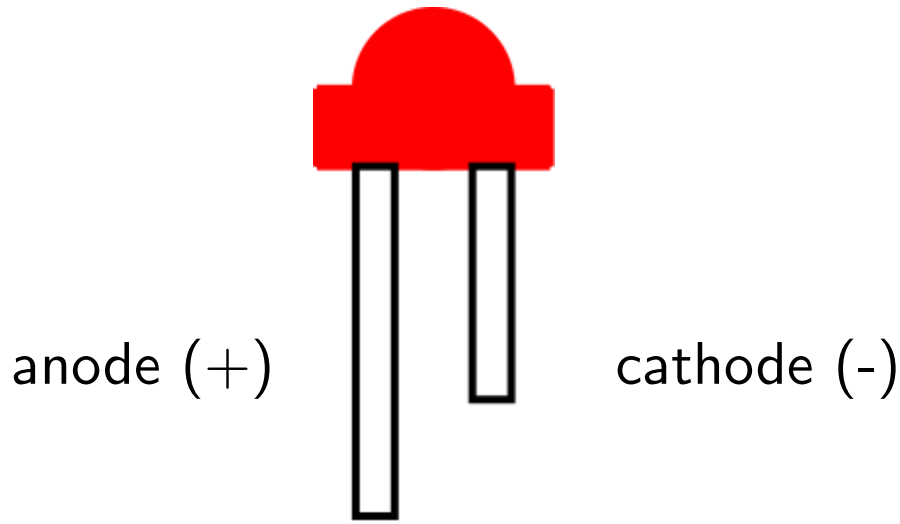


Reverse biased diode in a voltage divider

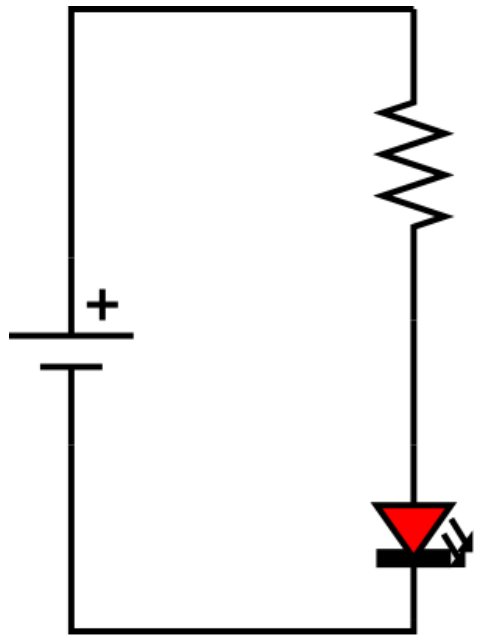


Reverse biased diode in a voltage divider

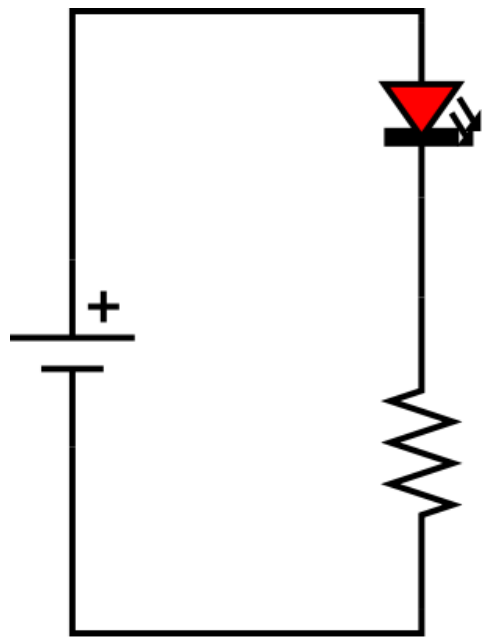
LEDs are a special case; they light up above a certain voltage. The voltage depends on the colour.



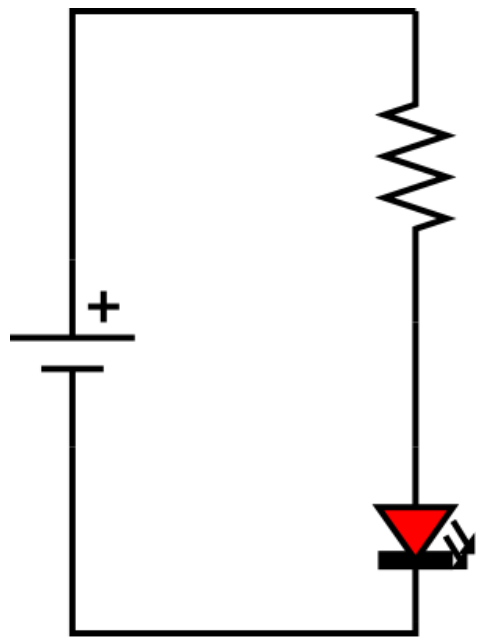
- The LED lights up when current flows from the anode to the cathode..



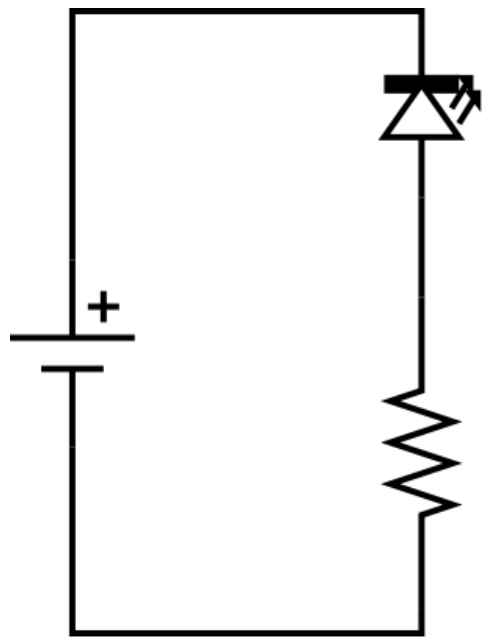
- You must use a resistor to limit the current.
- *Without a resistor, the LED will probably be destroyed.*



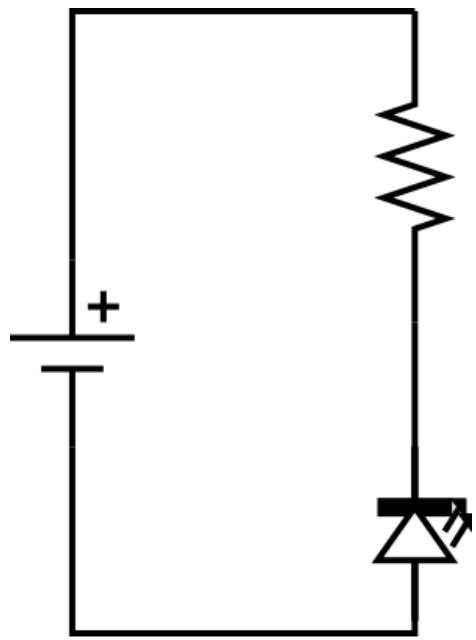
- The resistor can go before or after the LED.



- The resistor can go before or after the LED.



- Reverse-biased, the LED won't light up.



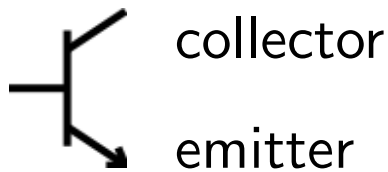
- Reverse-biased, the LED won't light up.

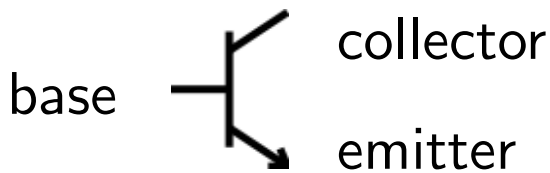
- There are several types of transistor; each is a three terminal device.

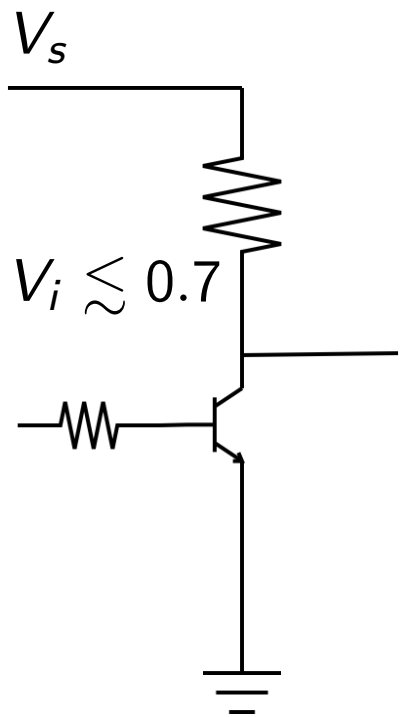
- There are several types of transistor; each is a three terminal device.
- The most common types of transistors are BJTs and FETs.

- There are several types of transistor; each is a three terminal device.
- The most common types of transistors are BJTs and FETs.
- Transistors are often used in voltage dividers to act as variable resistors.

collector

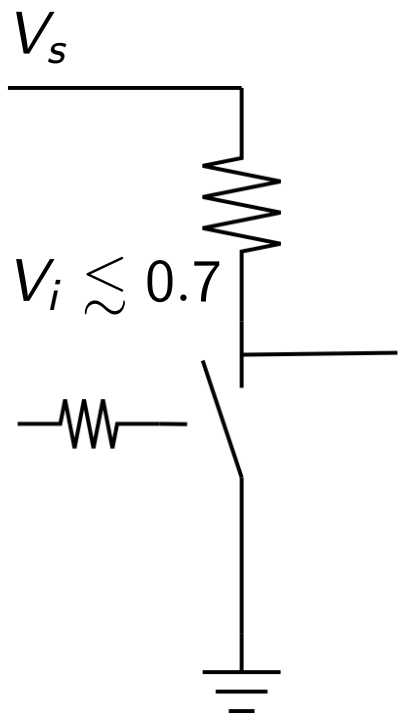

collector
emitter


base
collector
emitter



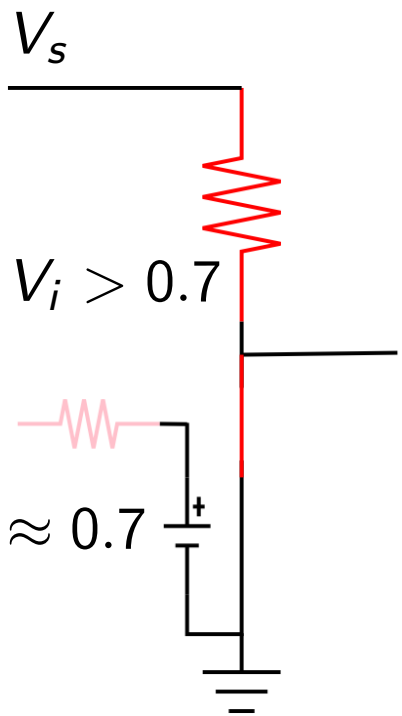
$V_o \approx V_s$ if $V_i \lesssim 0.7$

$I_c \approx 0$ if $V_i \lesssim 0.7$



$V_o \approx V_s$ if $V_i \lesssim 0.7$

$I_c \approx 0$ if $V_i \lesssim 0.7$



$V_o = V_s - I_c R$ if $V_i > 0.7$

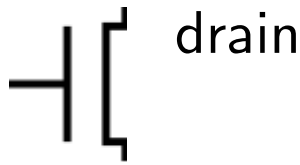
$I_c \propto I_b$ if $V_i > 0.7$

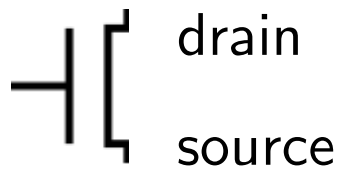
- BJTS are *current* amplifiers; a small **base** current controls a much larger **collector/emitter** current.

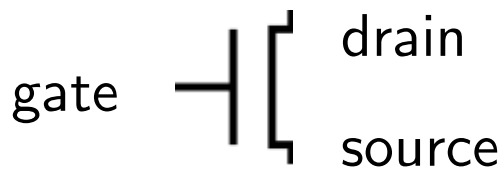
- BJTS are *current* amplifiers; a small **base** current controls a much larger **collector/emitter** current.
- *You should always have a base resistor with a BJT!*

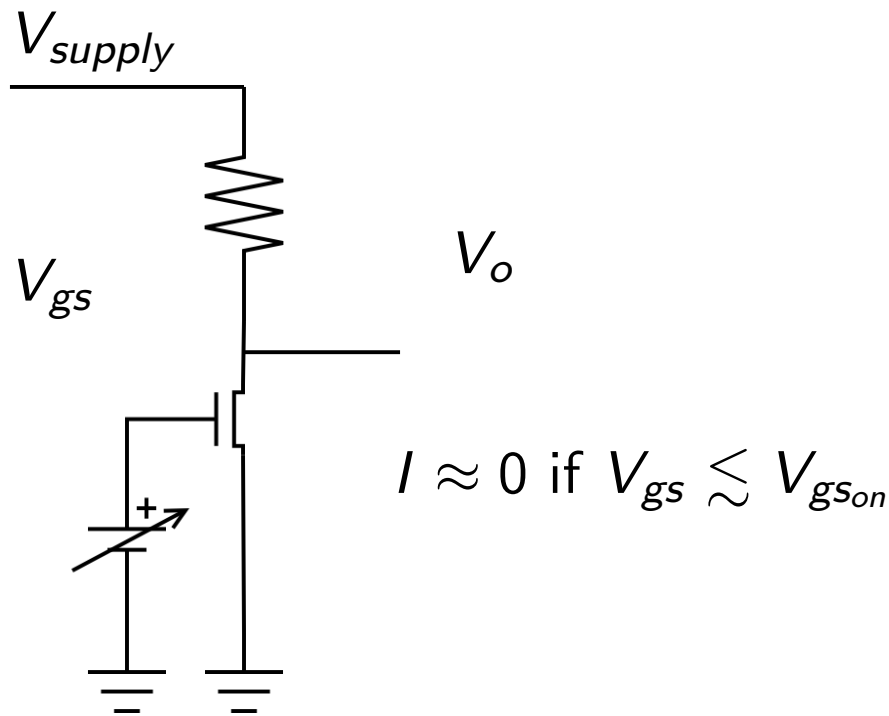
- FETS are *voltage* amplifiers; a small **gate** *voltage* controls a much larger **drain/source** *current*.

Actually it's the voltage between the gate and the source which matters.

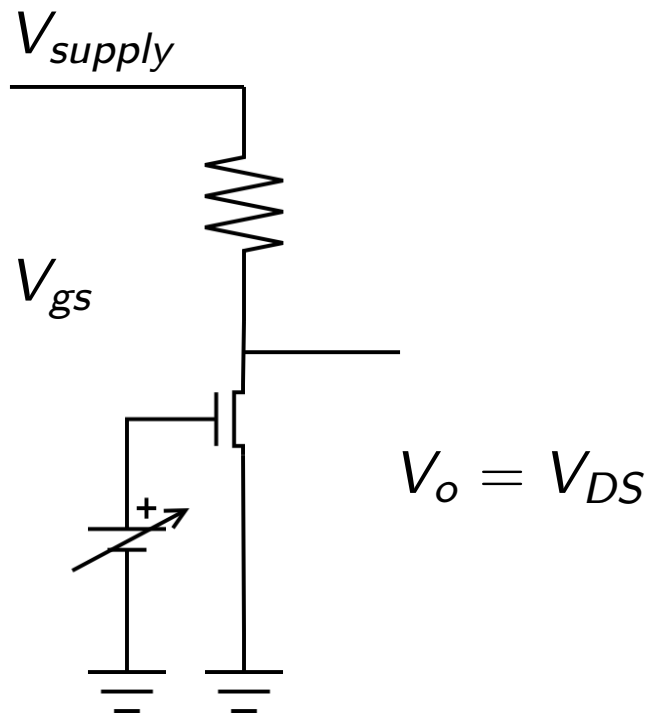

drain


drain
source

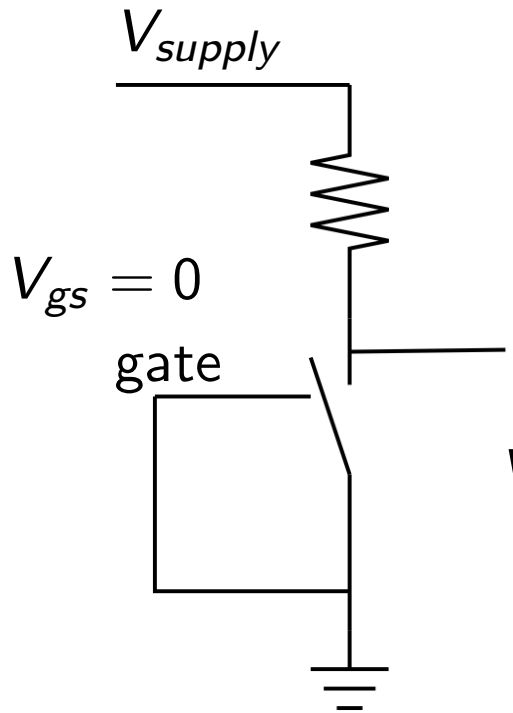

gate
drain
source



E (ehancement mode) FET

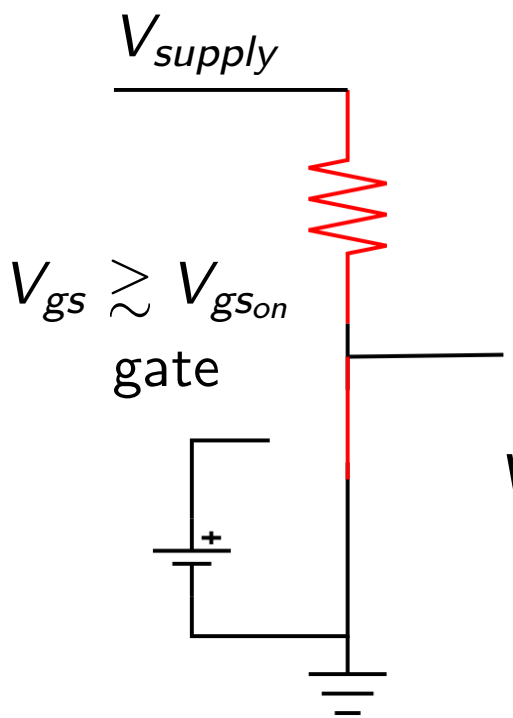


E (ehancement mode) FET



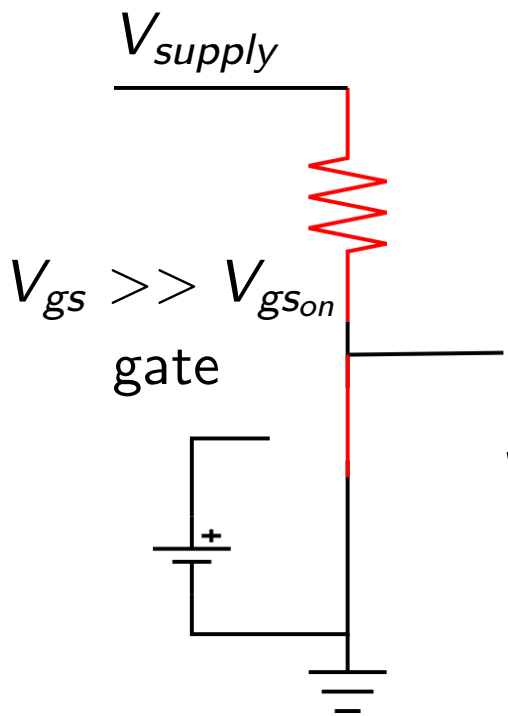
$V_o \approx V_{supply}$ if $V_{gs} < V_{gs_{on}}$

E (ehancement mode) FET



$$V_o = V_{DS} > 0 \text{ if } V_{gs} \gtrsim V_{gs_{on}}$$

E (ehancement mode) FET



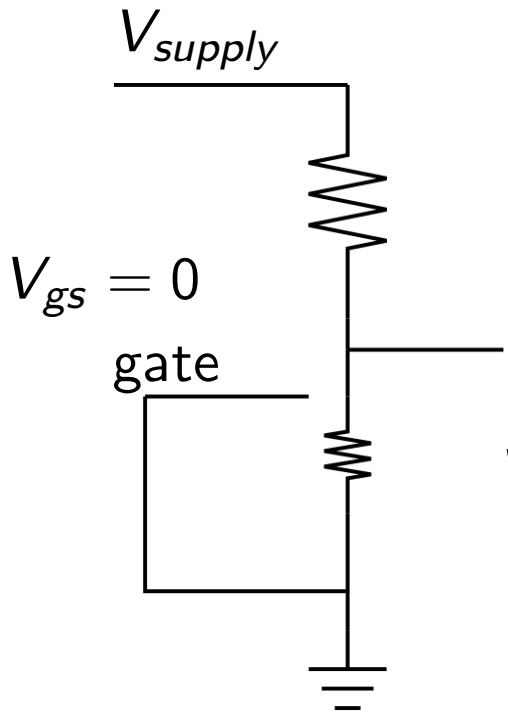
$$V_o = V_{DS} \rightarrow 0 \text{ if } V_{gs} >> V_{gs_{on}}$$

E (ehancement mode) FET

- FETS are *voltage* amplifiers; a small **gate-source** voltage controls a much larger **drain/source** current.

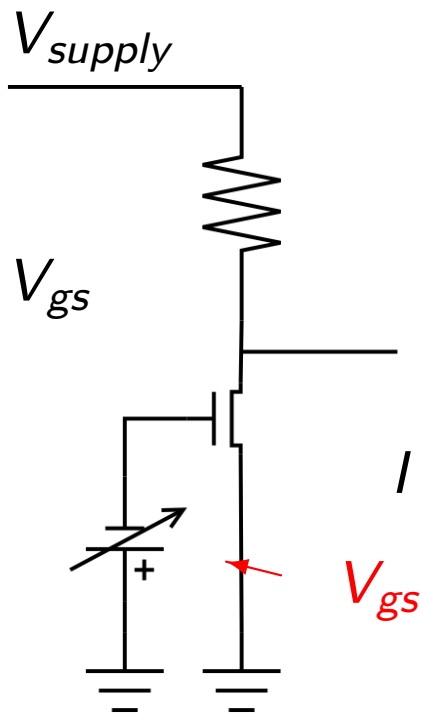
- FETS are *voltage* amplifiers; a small **gate-source** voltage controls a much larger **drain/source** current.
- *You do not use a gate resistor with an FET!*

- FETS are *voltage* amplifiers; a small **gate-source** voltage controls a much larger **drain/source** current.
- *You do not use a gate resistor with an FET!*
- All FETs work in *enhancement* mode; some also work in *depletion* mode.



$V_o = V_{DS} > 0$ if $V_{gs} = 0$

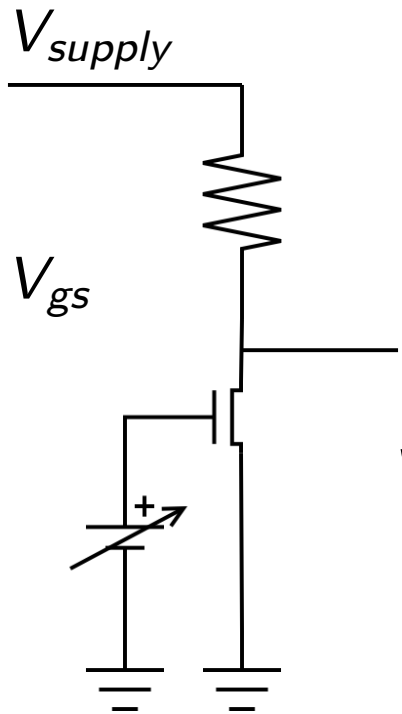
D (depletion mode) FET



$I \approx 0$ if $V_{gs} \lesssim V_{th} < 0$

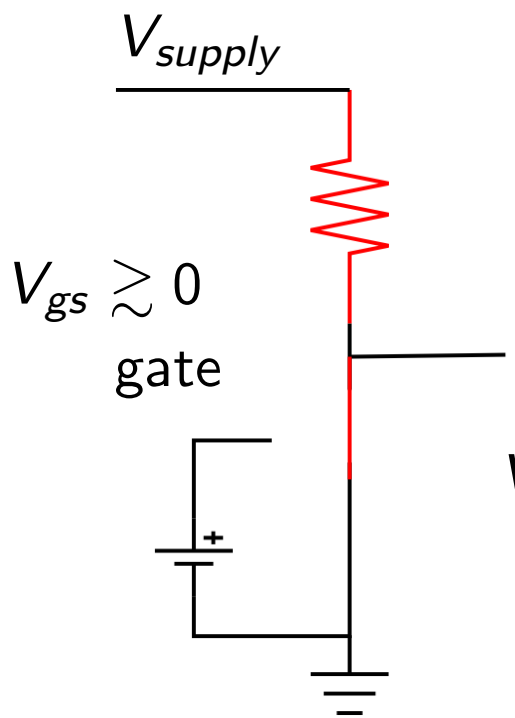
V_{gs} has to be negative to turn off.

D (depletion mode) FET



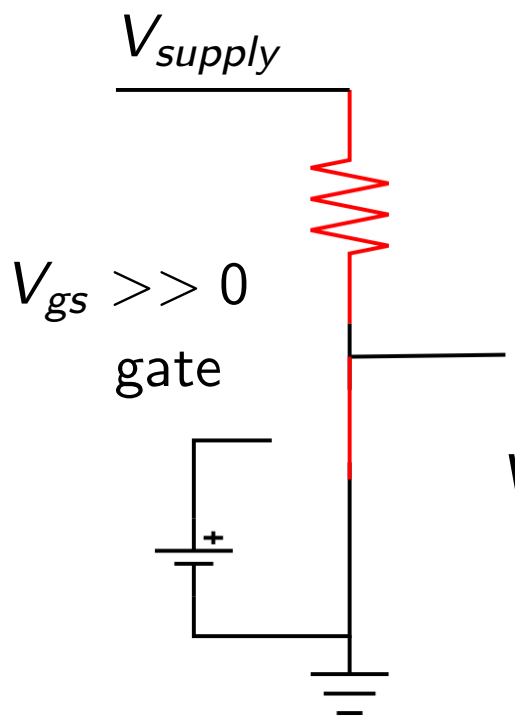
$$V_o = V_{DS} \approx 0 \text{ if } V_{gs} >> 0$$

D (depletion mode) FET



$V_o = V_{DS} > 0$ if $V_{gs} \gtrsim 0$

D (depletion mode) FET



$V_o = V_{DS} \rightarrow 0$ if $V_{gs} >> 0$

D (depletion mode) FET