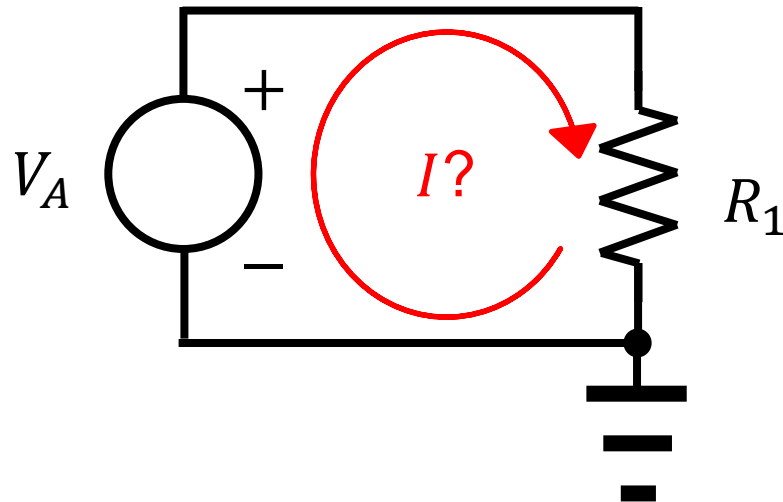

Lecture2: Circuit theory

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A simple problem

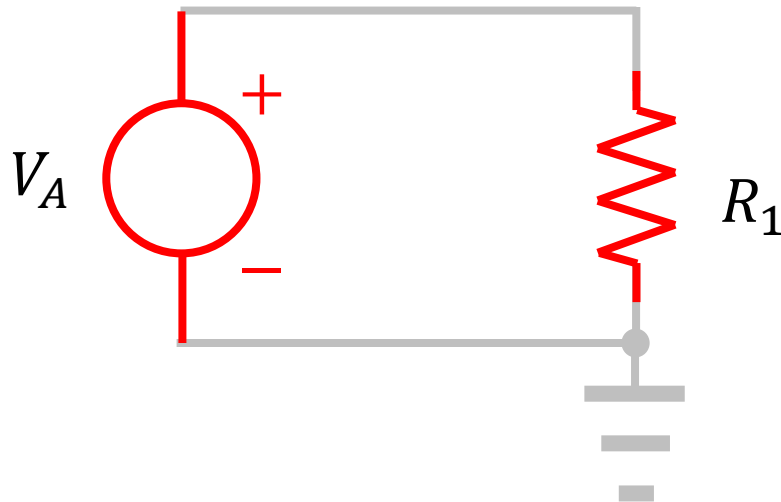
- Solve the problem.
 - What is the current?



- It is an easy problem.

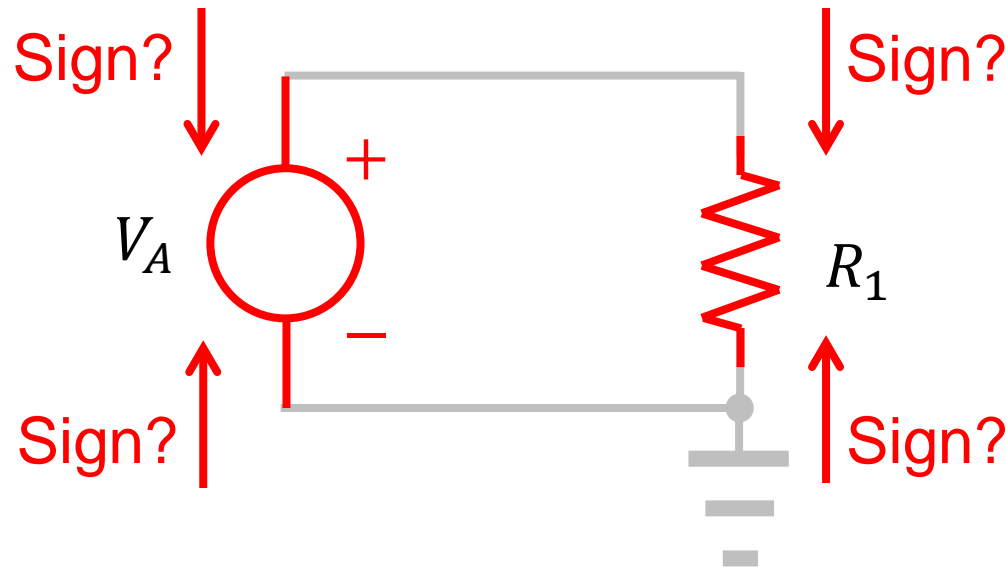
Elements

- Resistors, capacitors, etc
 - They can have multiple terminals.
 - A resistor has two terminals.
 - A diode has two terminals.
 - A MOSFET has three (or four) terminals.



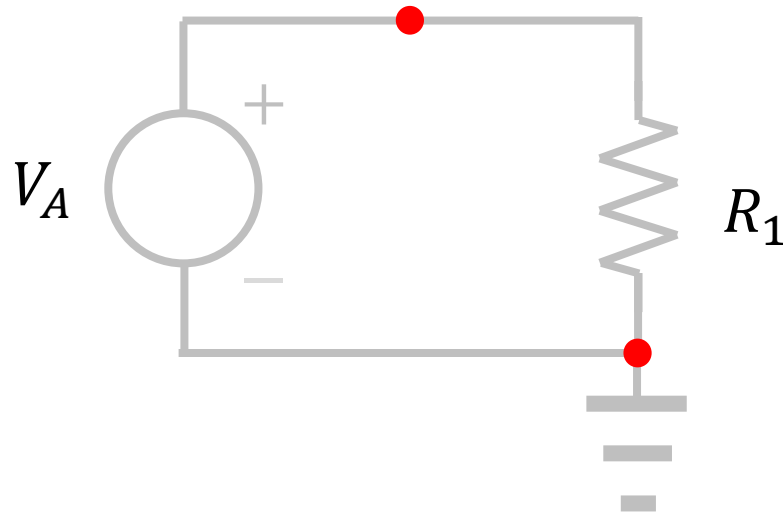
Convention for current

- Terminal current
 - Conventionally, an in-coming current is regarded as positive.



Nodes

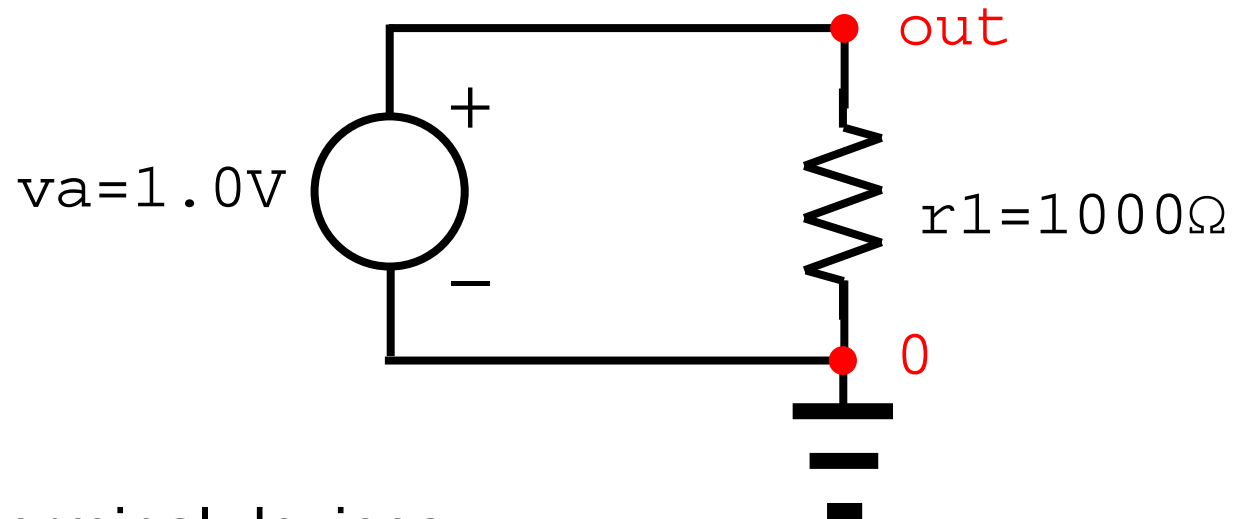
- A point to which multiple terminals are tied.
 - (Usually, a dot is used to represent a node.)
 - There is a special node, GND.



How to describe a circuit

- Of course, we can draw a circuit schematic. What else?
- A netlist for this circuit looks like:

```
va out 0 1.0  
r1 out 0 1000
```



- Format for two-terminal devices
elementlabel node1 node2 value

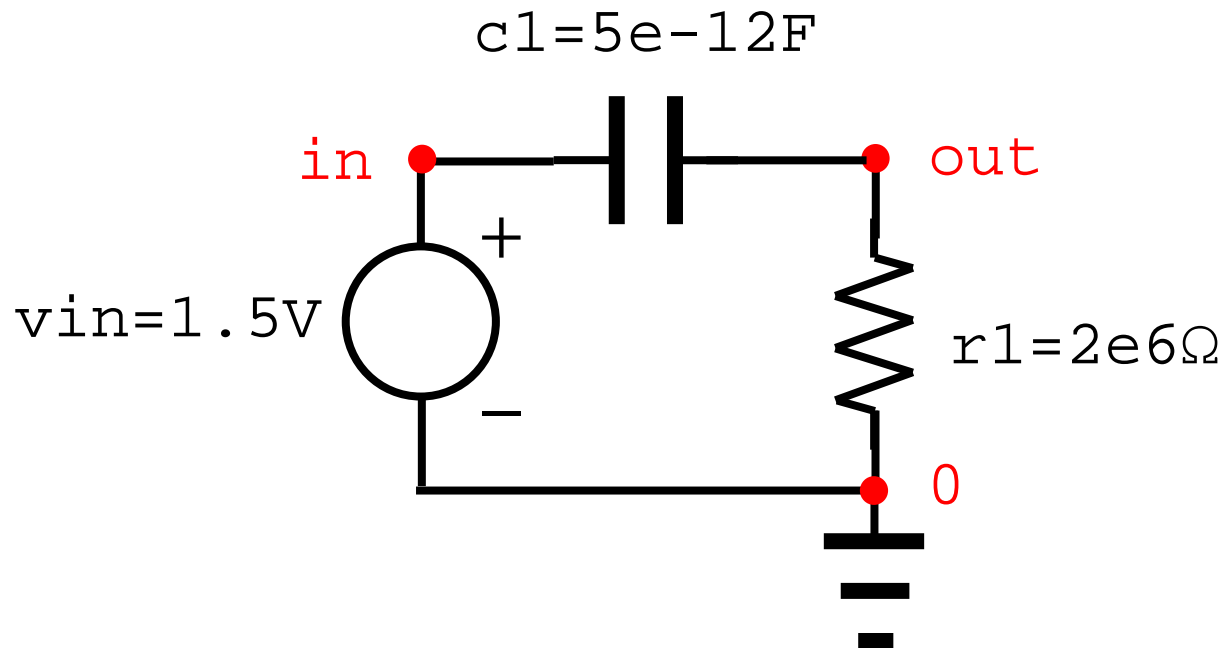
RC filter

- A netlist for this circuit looks like:

```
c1 in out 5e-12
```

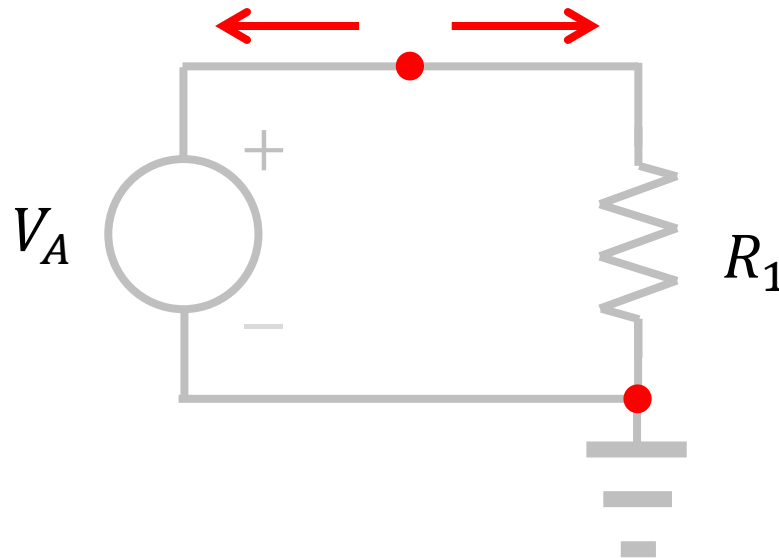
```
r1 out 0 2e6
```

```
vin in 0 1.5
```



Circuit analysis (1)

- The basic principle of circuit analysis is...
 - Kirchhoff's current law (KCL)!
 - At any node in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node.



Circuit analysis (2) – Optional

- Why do we have the KCL?

- According to the Maxwell equations,

$$\nabla \cdot \mathbf{J}_{tot} = 0$$

- Here, the total current density is a sum of the particle current density and the displacement current density:

$$\mathbf{J}_{tot} = \mathbf{J}_{particle} + \frac{\partial}{\partial t} \mathbf{D}$$

- By integrating \mathbf{J}_{tot} over a certain surface, we can calculate the current through that surface.
- Integration over a certain volume, V , yields

$$\int_V (\nabla \cdot \mathbf{J}_{tot}) d\mathbf{r} = \oint_S \mathbf{J}_{tot} \cdot d\mathbf{a} = \sum_i I_i = 0$$

- Here, S is the surface of V and I_i is a branch current.

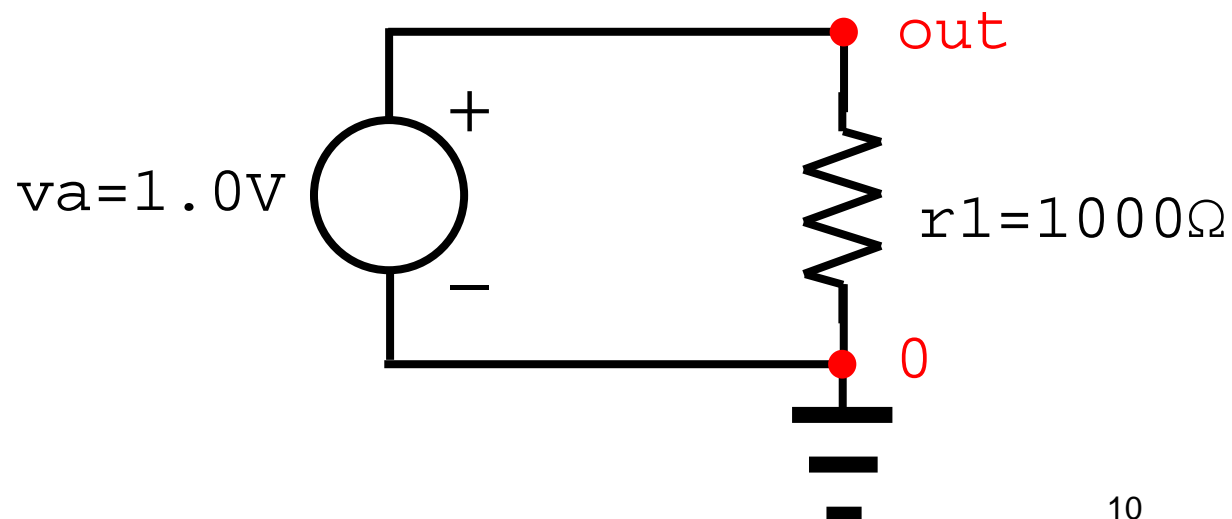
Circuit analysis (3)

- Our simple problem
 - Following equations are identified.

$$I_{va} + I_{r1} = 0 \quad \text{KCL}$$

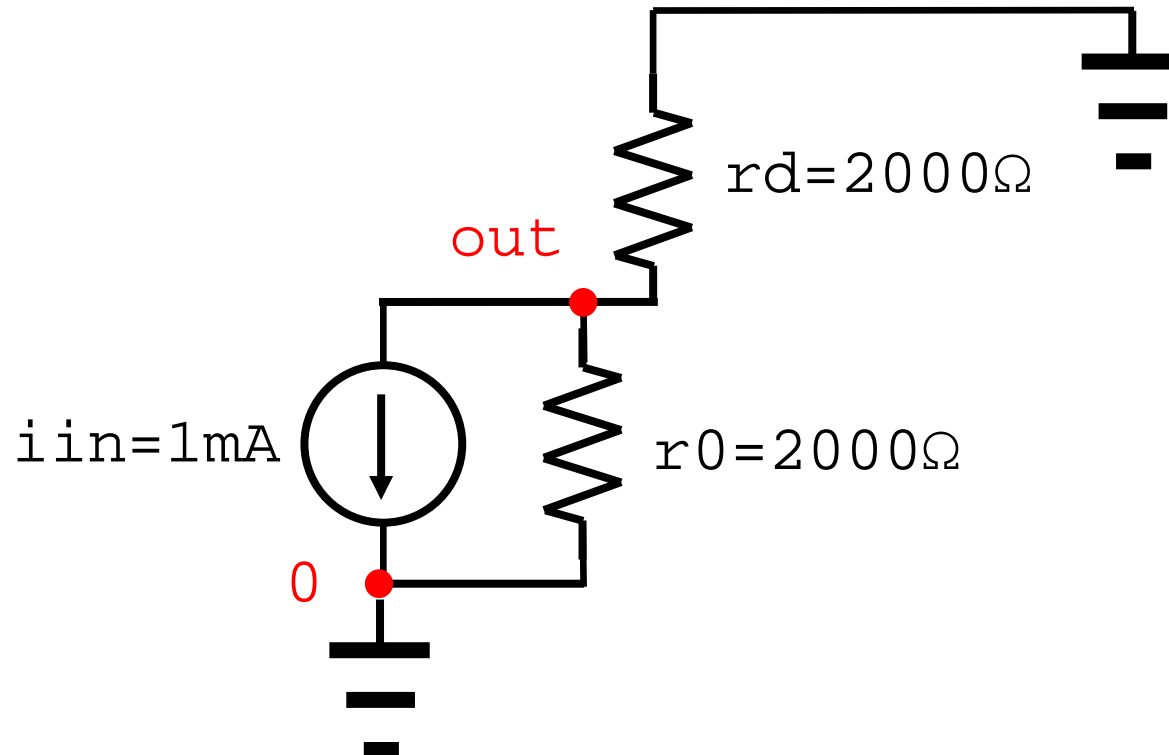
$$V(out) - 0.0 = 1.0 \quad \text{Voltage source}$$

$$I_{r1} = \frac{V(out)}{1000} \quad \text{Resistor}$$



Circuit analysis (4)

- Our real-world example
 - Write a netlist.
 - Calculate the node voltage of `out`.



Homework#1

- Due: 09:00, March 11
 - Submit your Homework answer sheet (hardcopy) directly to Mr. Suhyeong Cha, our TA.
 - His office: EECS building C-411
- Draw a circuit schematic of the following netlist.
v1 batt 0 1.5
rchar batt anode 1e6
cchar anode 0 1e-9
rpcss anode cathode 21
rload cathode 0 50
- Calculate the DC cathode voltage.