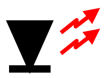
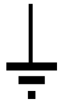
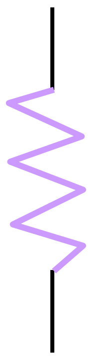
What you are expected to know

- Ohm's Law
- Series & Parallel
- Kirchhoff's Rules
- Short circuits
- RC Circuit behaviour
- LEDs let current flow in only one direction

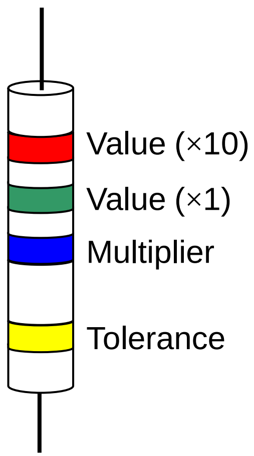
LED 

GND 

Resistor Colour Code



Schematic Symbol



Colour	Value	Multiplier
Black	0	10^0
Brown	1	10^1
Red	2	10^2
Orange	3	10^3
Yellow	4	10^4
Green	5	10^5
Blue	6	10^6
Violet	7	10^7
Gray	8	10^8
White	9	10^9

Colour	Tolerance
Gold	5%
Silver	10%
None	20%

Hint – Use an ohmmeter!

Electronics Circuit Diagrams

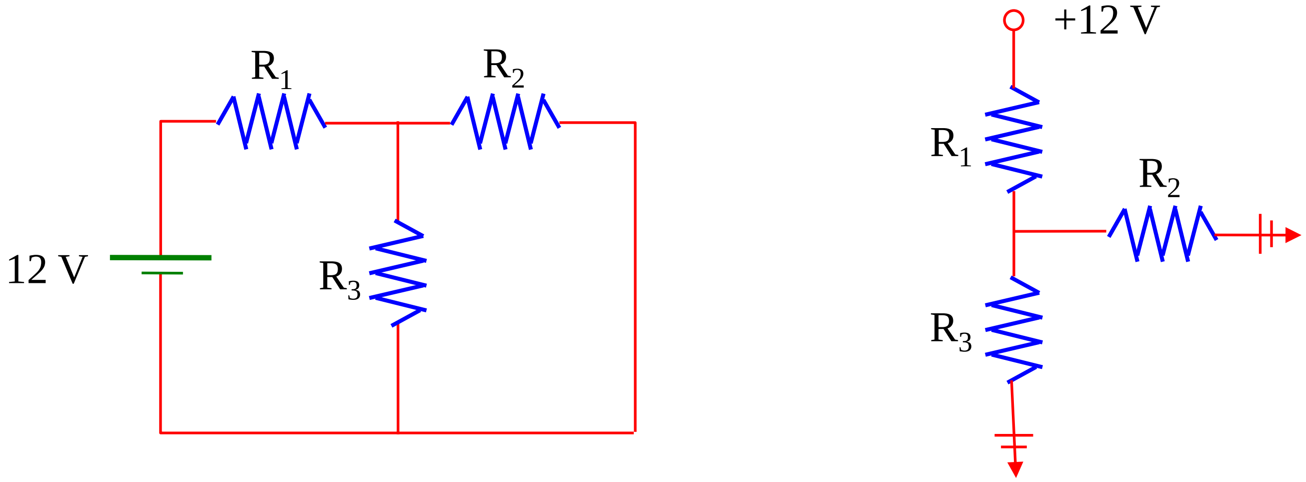
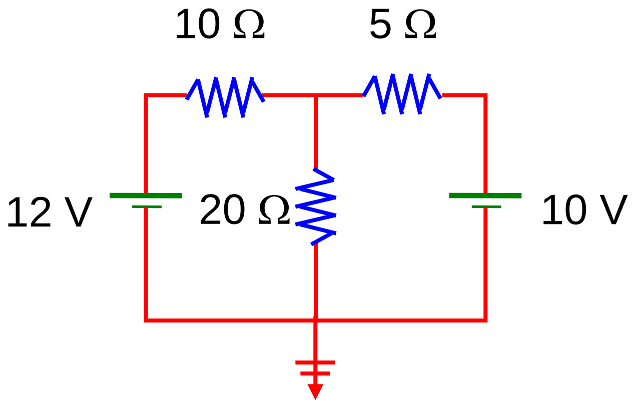
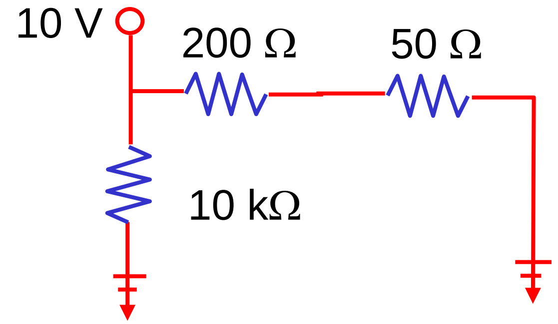


Figure IV-8: Standard and electronics style circuit diagrams.

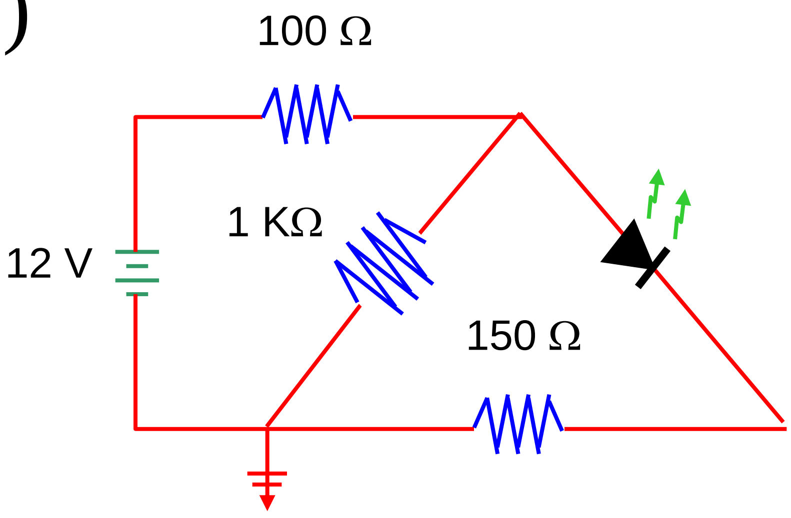
(a)


10 Ω
5 Ω
12 V
20 Ω
10 V

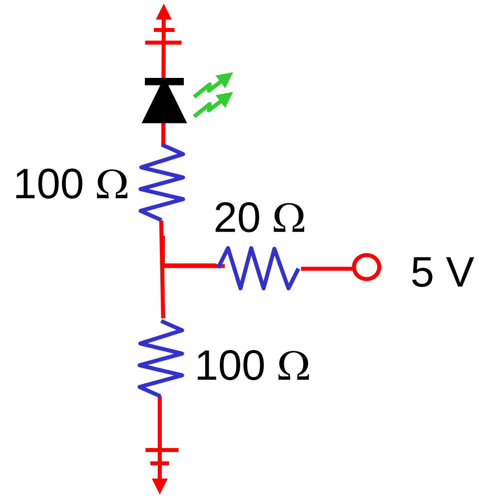
(c)


10 V
200 Ω
50 Ω
10 kΩ

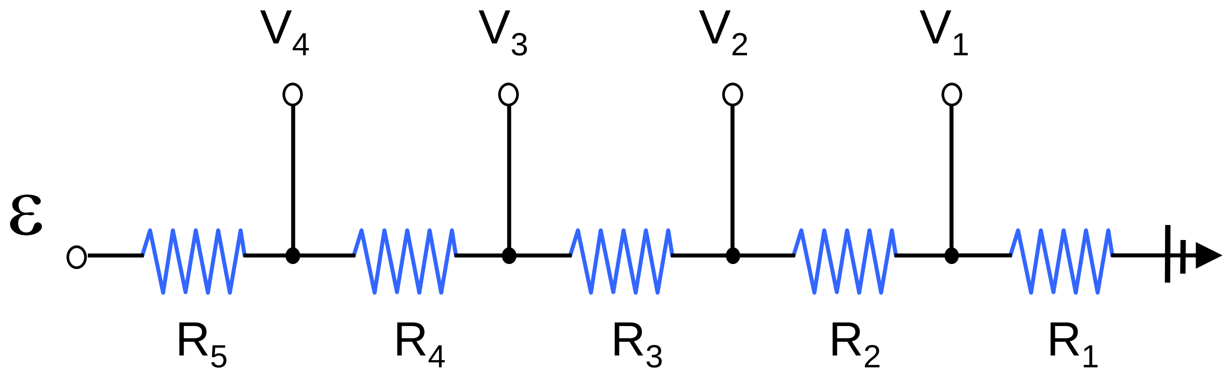
(b)


100 Ω
1 KΩ
12 V
150 Ω

(d)

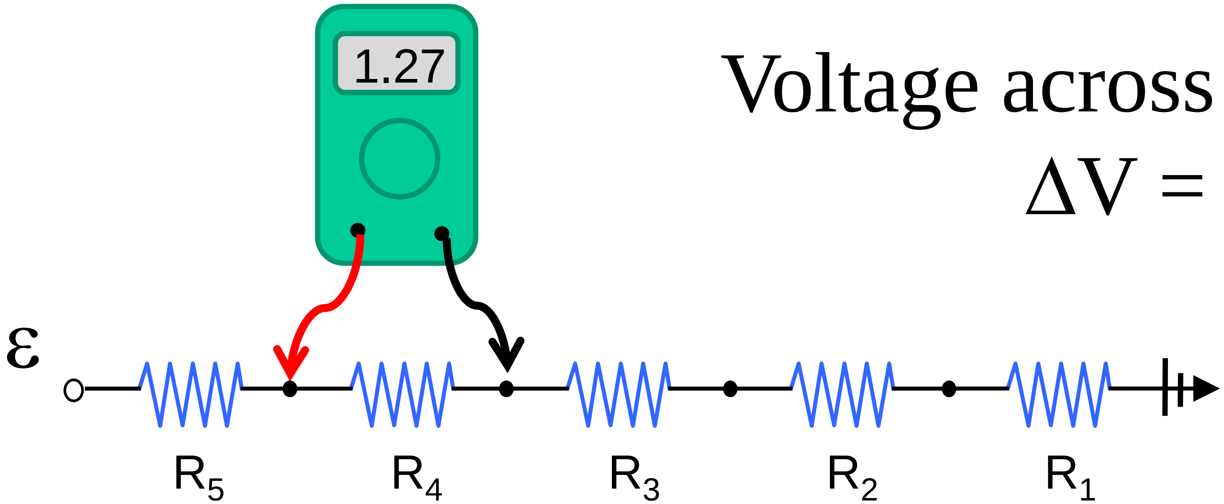

100 Ω
20 Ω
5 V
100 Ω

Voltage Divider



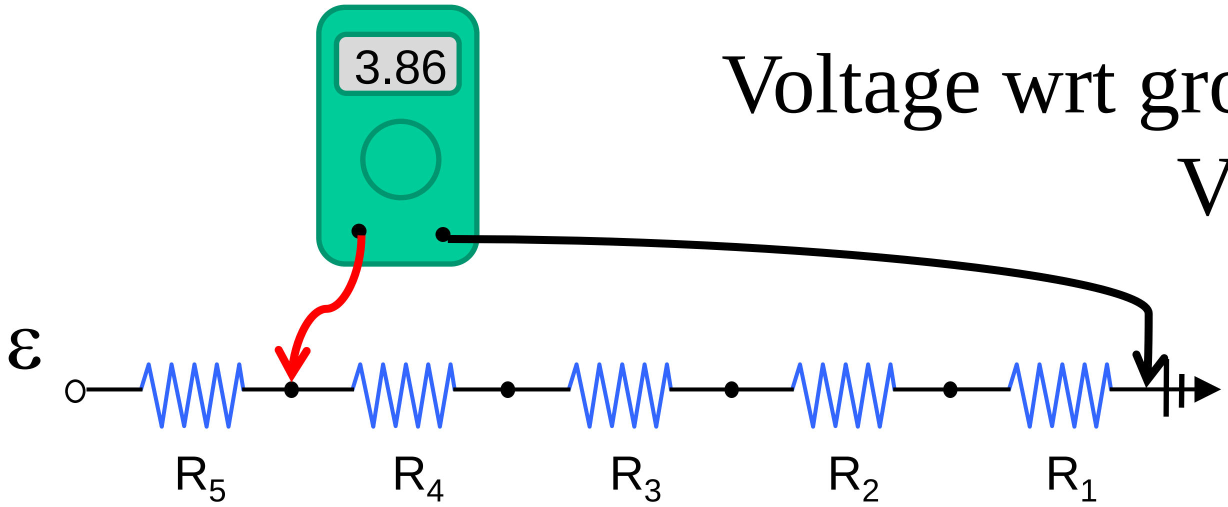
$$V_n = \frac{R_1 + \cdots + R_n}{R_{Total}} \mathcal{E}$$

V_n is voltage wrt ground



Voltage across = voltage drop

$$\Delta V = I \times R_4$$

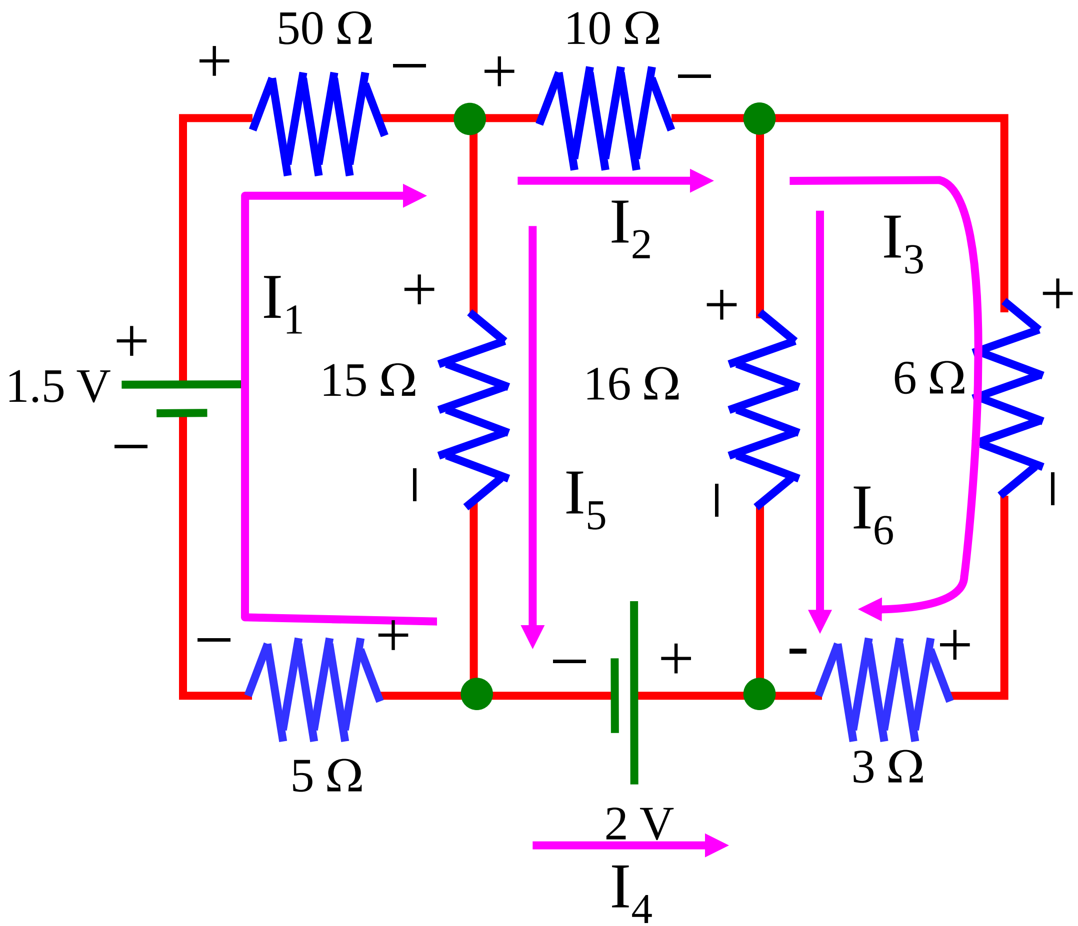


Voltage wrt ground = voltage

$$V_4$$

Using Kirchhoff's Rules

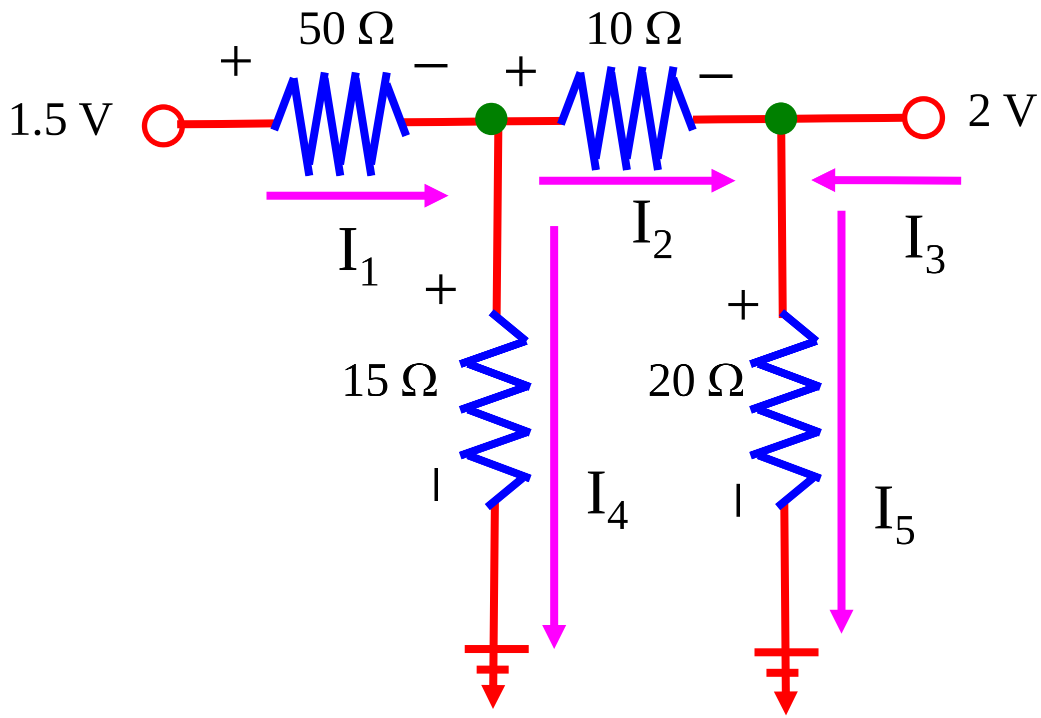
- We use conventional (+) current
- Node/Junction: 3 or more wires join
- Branch: Path from one node to next
  - Assume one current and direction per branch
  - Current flows from high (+) to low (-)
  - $\Delta V = -IR$ if go in direction of current
  - $\Delta V = +IR$ if go opposite to current
- Sum of ΔV's around loop = 0 (KR1)
- Current Into node = current out (KR2)



$$1.5 - 50I_1 - 15I_5 - 5I_1 = 0 \qquad I_1 = I_2 + I_5$$

$$2 + 16I_6 + 10I_2 - 15I_5 = 0 \qquad I_2 = I_3 + I_6$$

$$-6I_3 - 3I_3 + 16I_6 = 0 \qquad I_6 + I_3 + I_4 = 0$$



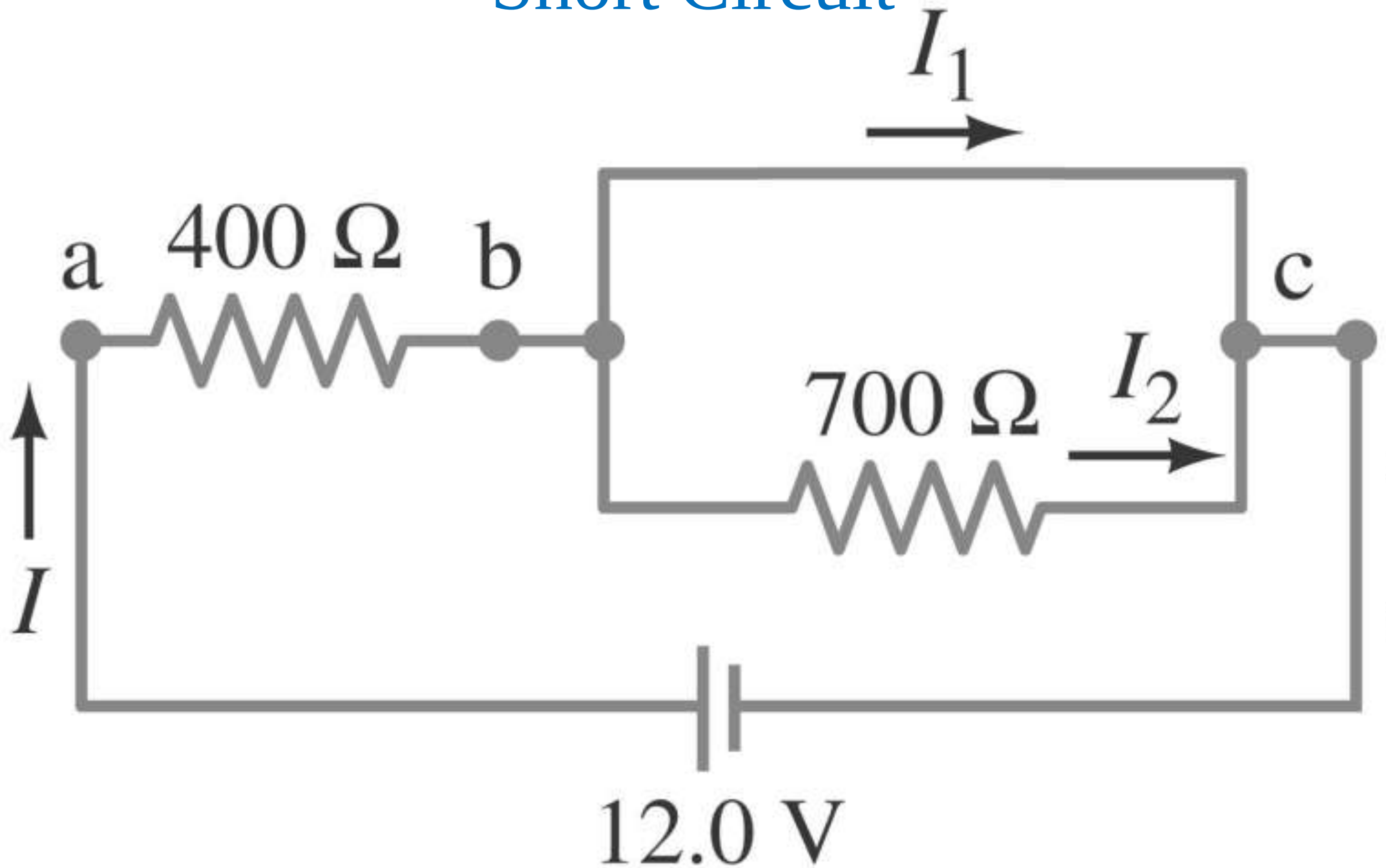
$$1.5 - 50I_1 - 15I_4 = 0$$

$$1.5 - 50I_1 - 10I_2 - 20I_5 = 0 \qquad I_1 = I_2 + I_4$$

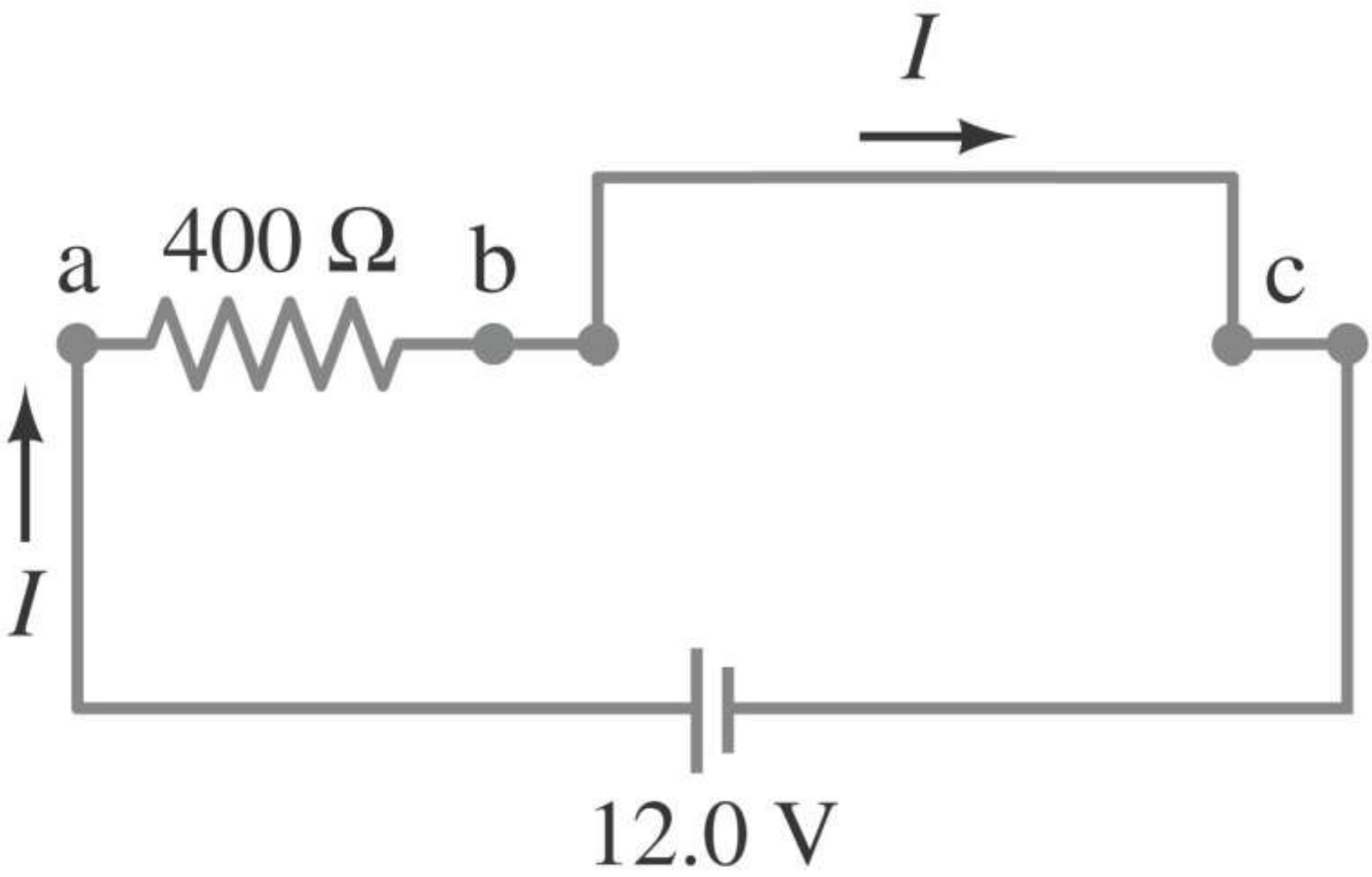
$$2 - 20I_5 = 0 \qquad I_5 = I_2 + I_3$$

$$2 + 10I_2 - 15I_5 = 0$$

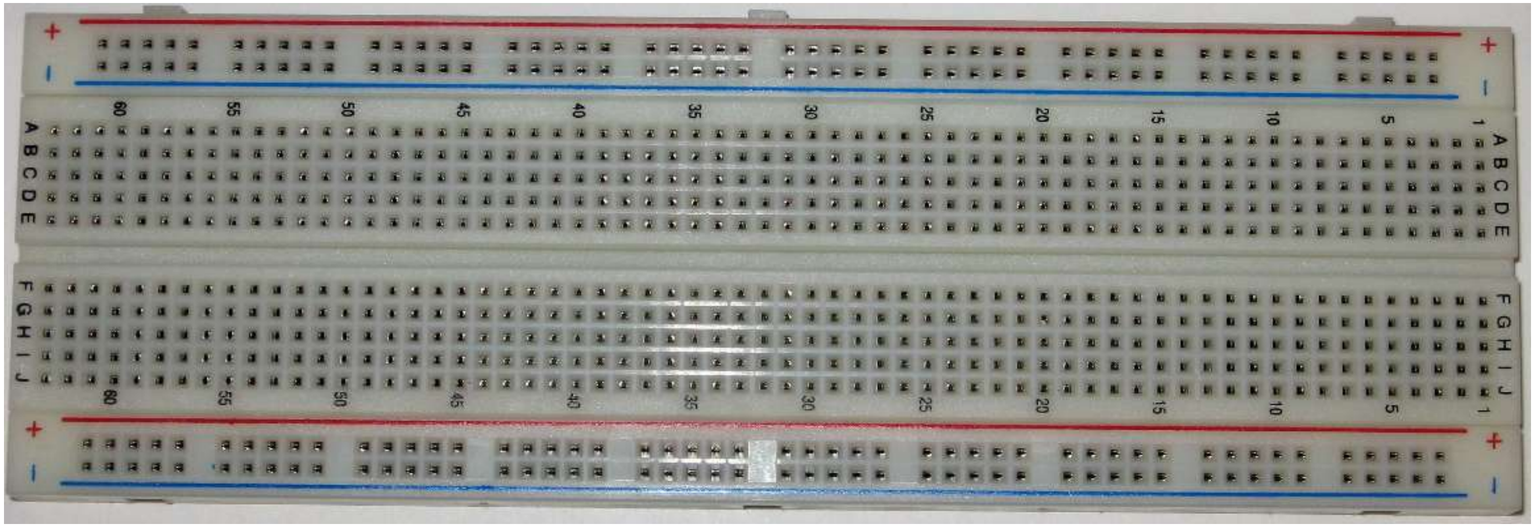
Short Circuit

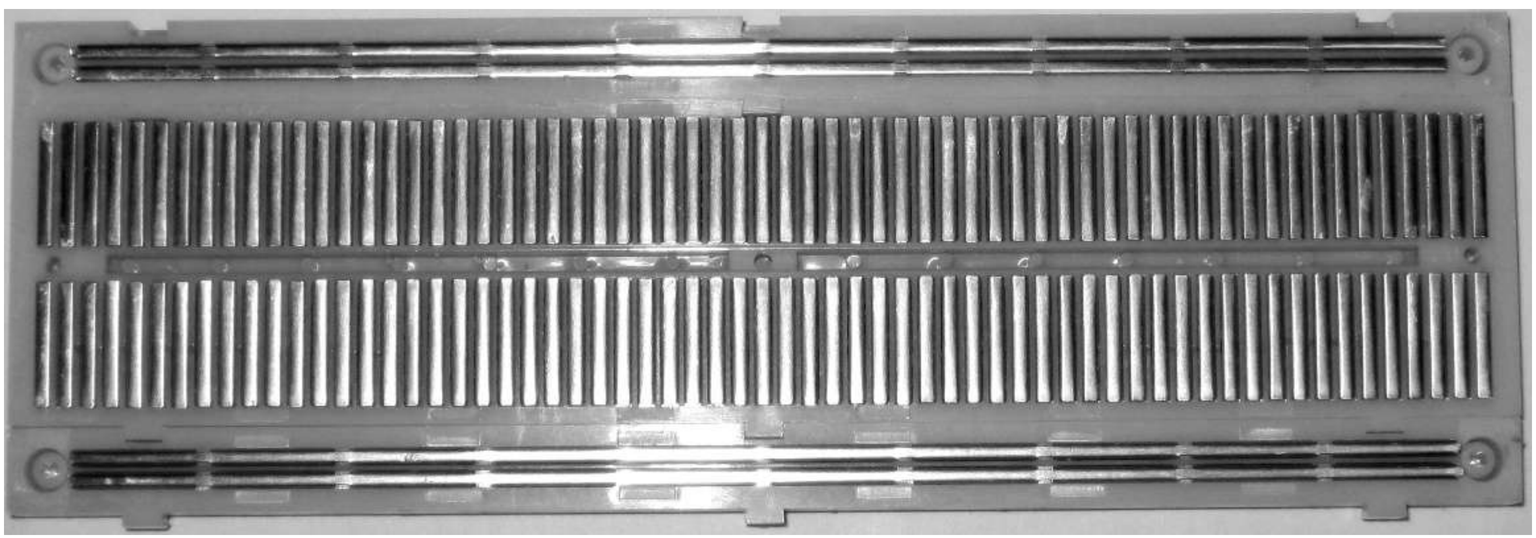


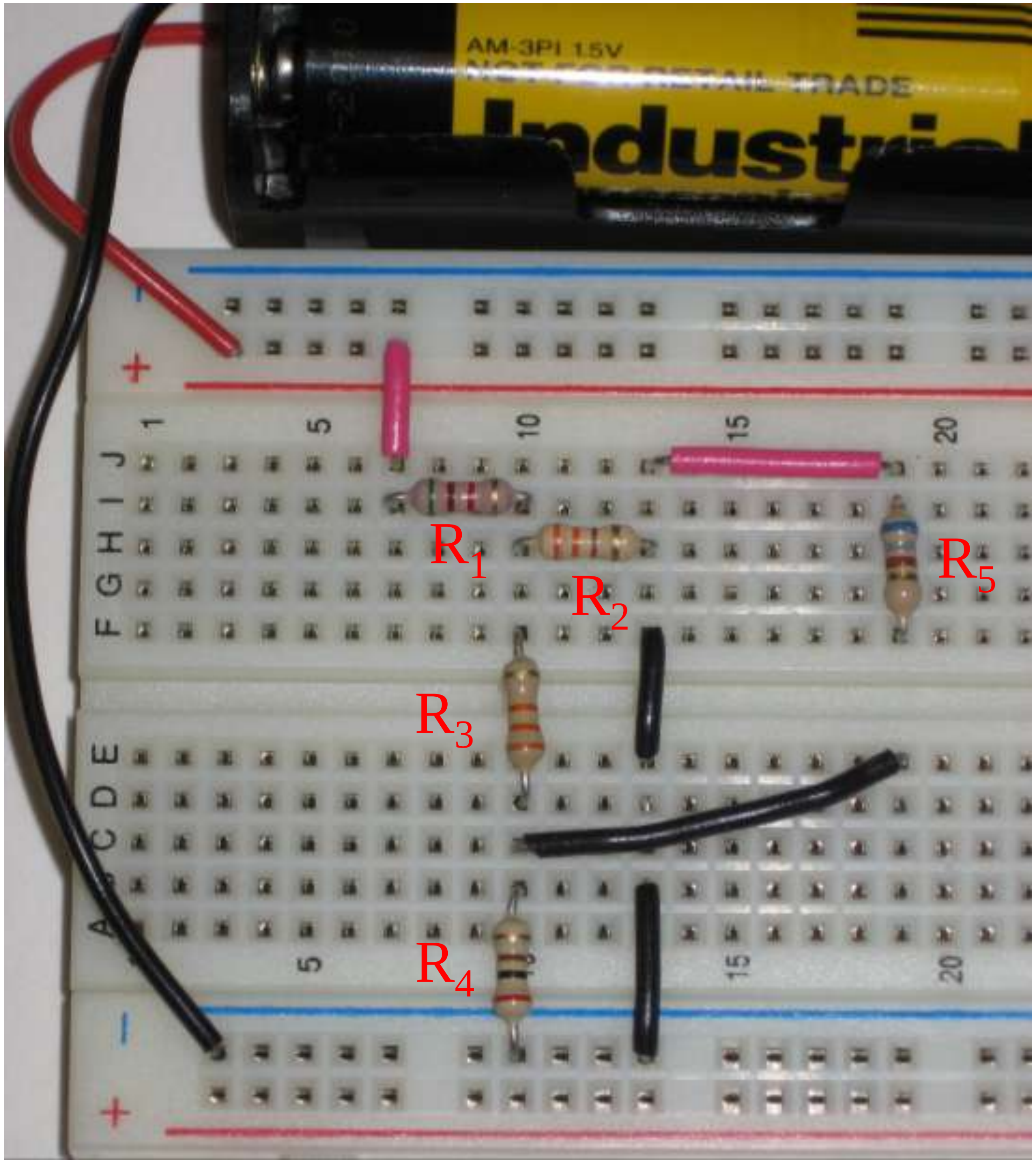
(a)

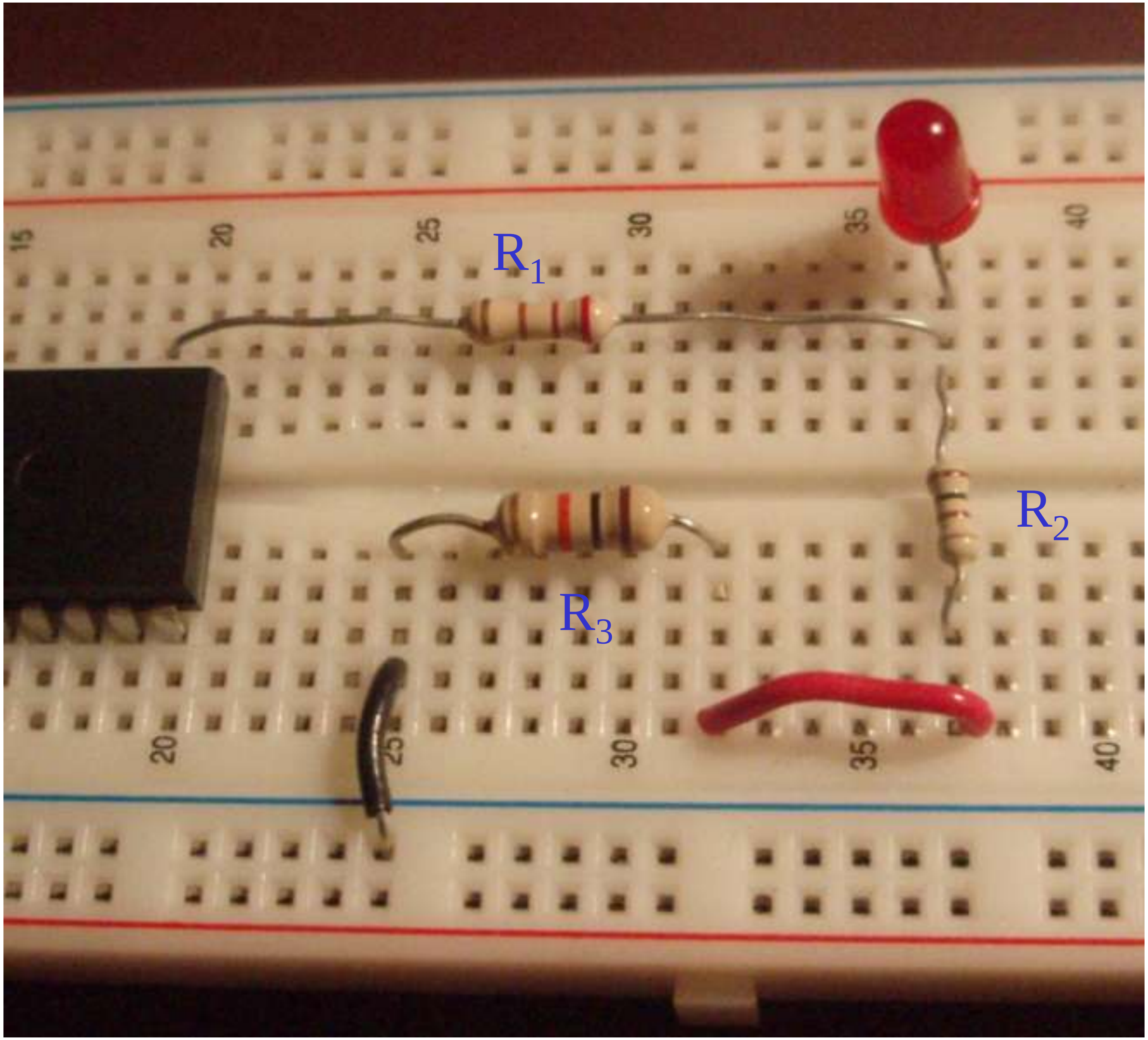


(a)


+
-
60 55 50 45 40 35 30 25 20 15 10 5 1
A B C D E
F G H I J



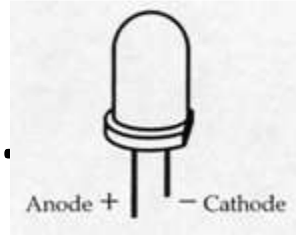

AM-3PI 1.5V
R_1
R_2
R_3
R_4
R_5


R_1
R_2
R_3

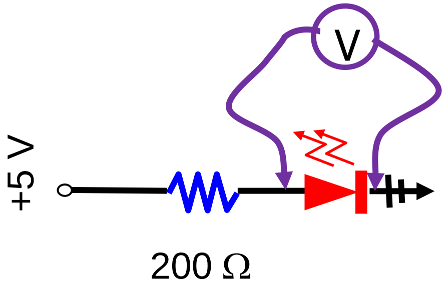
LED

- Conventional current only flows one way

- Notch on cathode (–) end. Leg shorter.

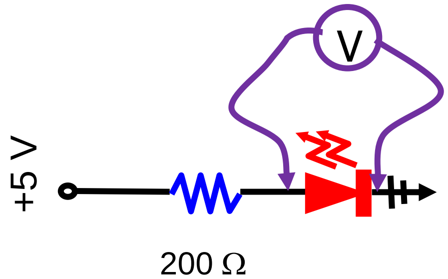


- Operates at ~2 Volts.

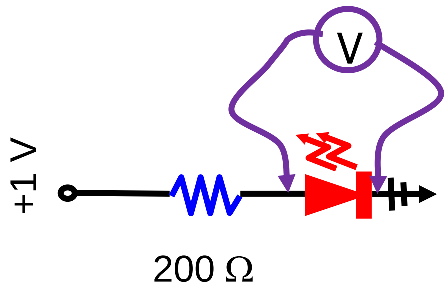


- Resistor controls current and brightness.

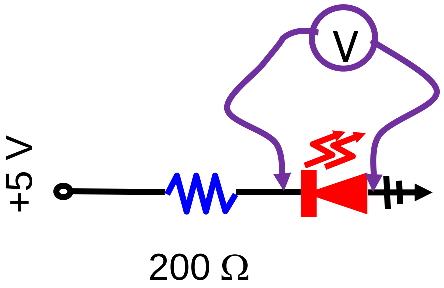
LED Circuits



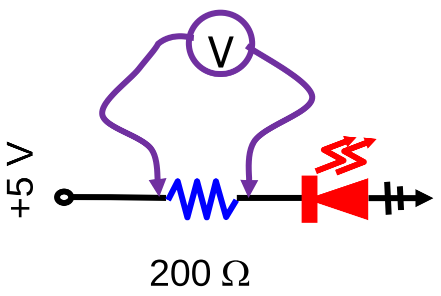
- Assume Forward biased – V_F = 2 V
- 5 = (200)I + 2
- Since I > 0, assumption is true



- Assume Forward biased
- 1 = (200)I + 2
- Since I < 0, assumption not true
- I = 0
- 1 = (200)(0) + V_{LED}

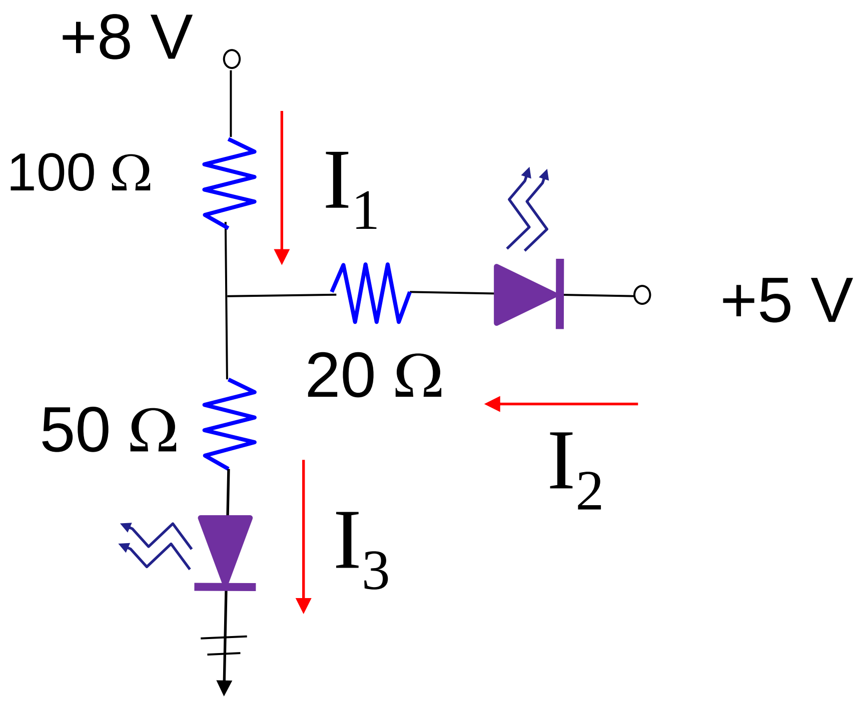


Cannot use voltmeter across reverse-biased LED. The LED has a huge effective resistance. Voltmeters only accurate if $R \ll R_{voltmeter}$.



Workaround:

$$5 = \Delta V_{resistor} + \Delta V_{LED}$$



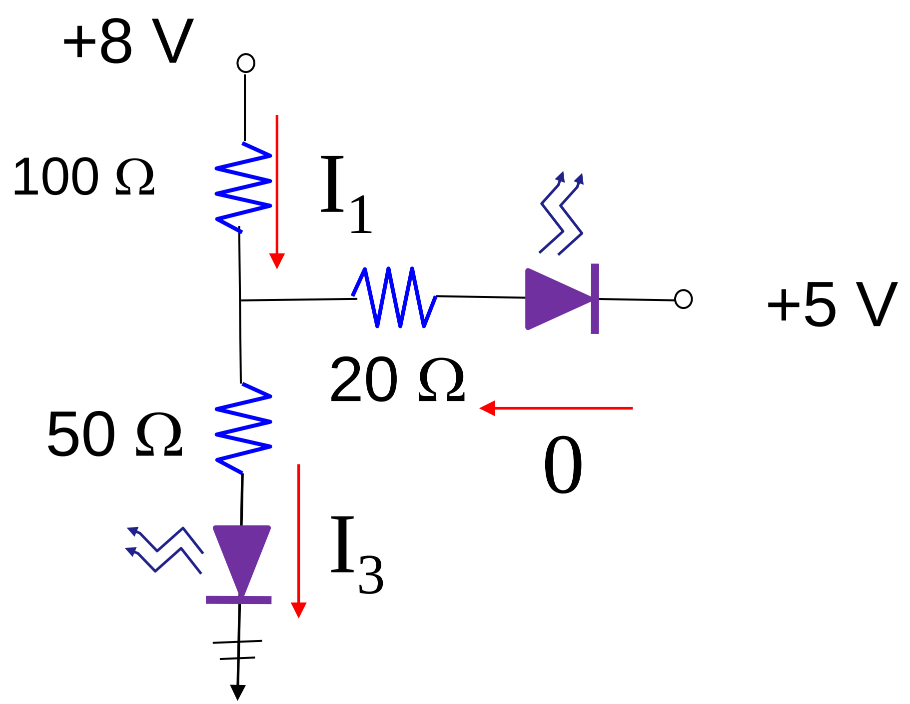
Assume current flow through LEDs correctly

$$I_1 + I_2 = I_3$$

$$8\text{ V} = (100\ \Omega)I_1 + (50\ \Omega)I_3 + V_{LEDB}$$

$$5\text{ V} = -V_{LEDA} + (20\ \Omega)I_2 + (50\ \Omega)I_3 + V_{LEDB}$$

$I_1 = 37/800$ A, $I_2 = -3/160$ A, and $I_3 = 22/800$ A

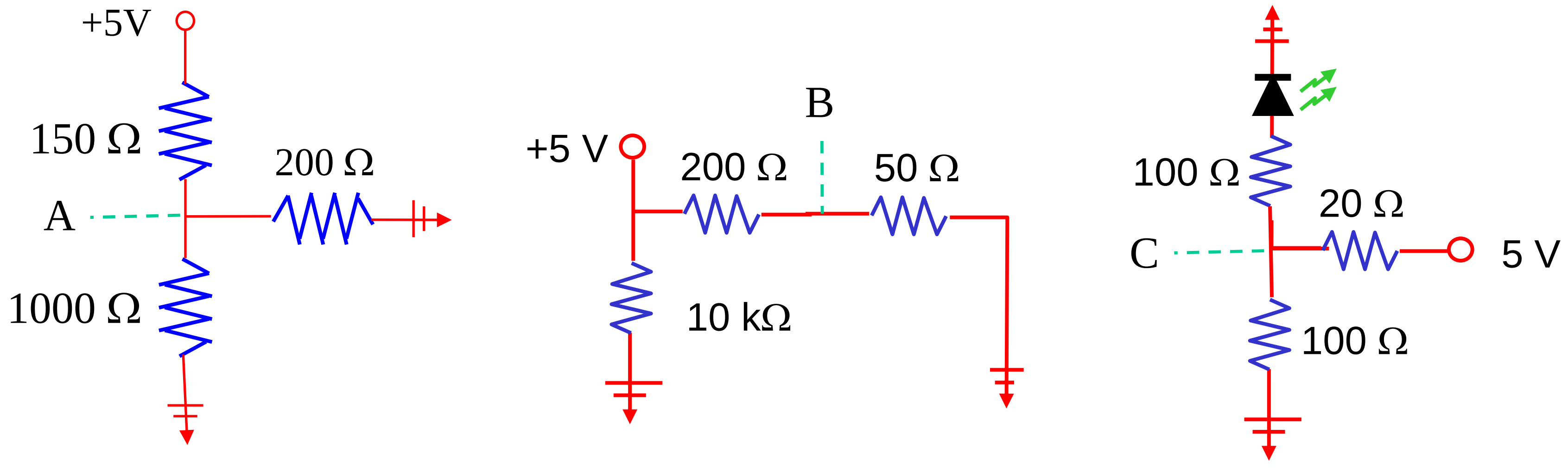


Since current cannot be negative, $I_2 = 0$!

$$I_1 + 0 = I_3$$
$$8\text{ V} = (100\ \Omega)I_1 + (50\ \Omega)I_3 + V_{LEDB}$$
$$5\text{ V} = -V_{LEDA} - (20\ \Omega)0 + (50\ \Omega)I_3 + V_{LEDB}$$

$$I_1 = I_3 = 6/150\text{ A, and } V_{LEDA} = -1\text{ V}$$

Sketch what these circuits look like on a breadboard



What is the voltage wrt ground at the indicated points?