Two new (strange) elements:

Nullator $V=0$, $I=0$

just a circle – nothing in it

Norator V = arbitrary
I = arbitrary

two circles – looks like infinity

NO numbers

Review –

Voltage source : V = specified
I = arbitrary

Current source : V = arbitrary
I = specified.

Short : $V=0$
I = arbitrary

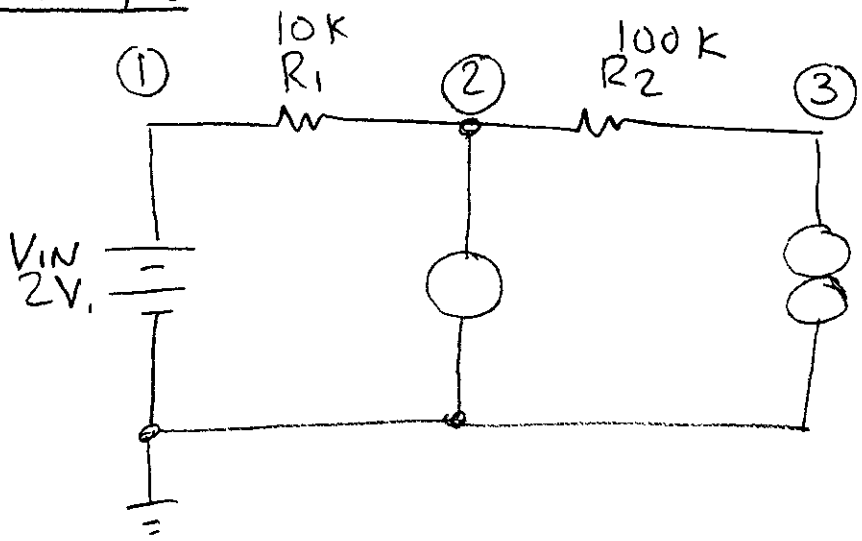
Open : V = arbitrary
$I=0$

Nullator, Norator always are in pairs,

For a circuit to be solvable,

nullators = # norators

Example



Node equations (ignore Nullator, treat Norator like voltage source)

① Can't do it — I is arbitrary

② $$\frac{V_2 - V_1}{R_1} + \frac{V_2 - V_3}{R_2} = 0$$

③ Can't do it — I is arbitrary — (like a voltage source)

Voltage sources

$$V_1 = V_{IN} = 2$$

Nullators (treat like short).

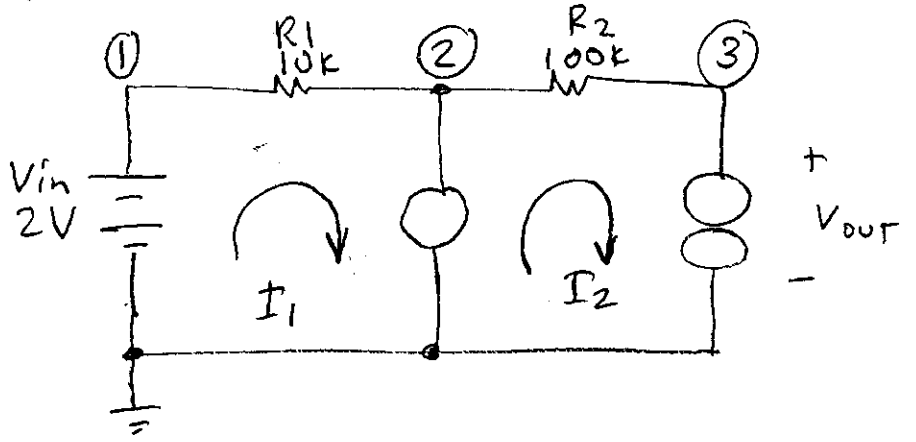
$$V_2 = 0$$

plug in:

$$\frac{0 - 2}{10K} + \frac{0 - V_3}{100K} = 0$$

$$\frac{-2}{10K} = \frac{V_3}{100K} \rightarrow V_3 = 100K\frac{-2}{10K} = -20$$

Loop equations:



Nullator and norator must be in same loop.

Norator has its own loop (like a current source)

Nullator must share a loop.

① $-V_{IN} - R_1 I_1 = 0$

② $R_2 I_2 + V_{OUT} = 0$

Nullator: $I_1 - I_2 = 0 \quad \Rightarrow I_1 = -I_2$

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solve: ① $V_{IN} = -R_1 I_1$

$$I_1 = -\frac{V_{in}}{R_1}$$

$$I_2 = -I_1 = \frac{V_{in}}{R_1}$$

② $R_2 \frac{V_{in}}{R_1} + V_{OUT} = 0$

$$V_{OUT} = -\frac{R_2}{R_1} V_{in}$$

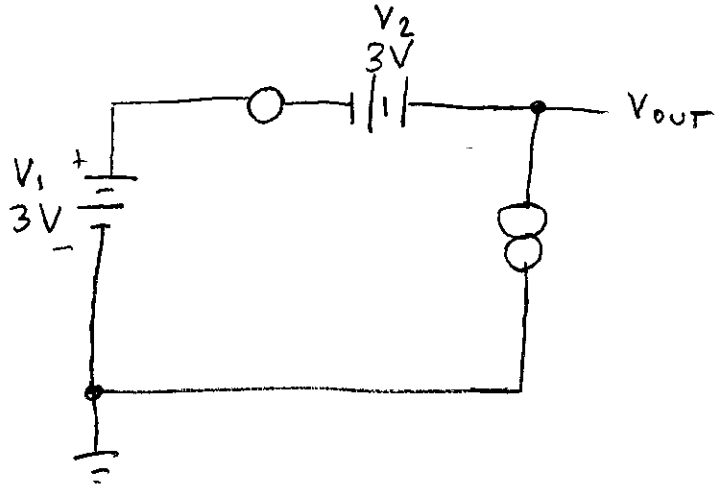
Substitute:

$$V_{OUT} = -\left(\frac{100K}{10K}\right)(2)$$

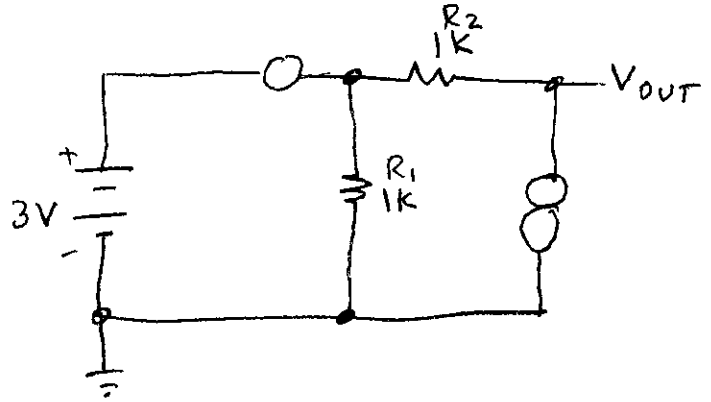
$$= -20$$

Homework Find V_{OUT}

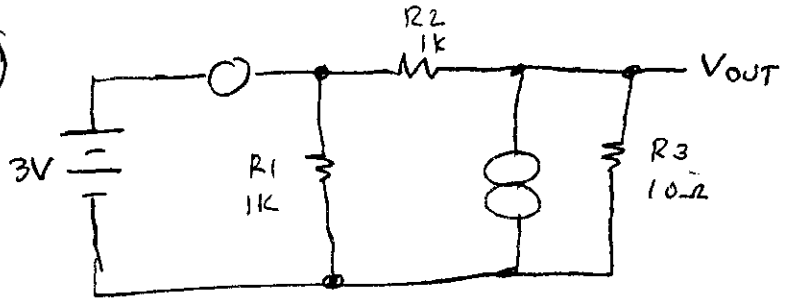
1)



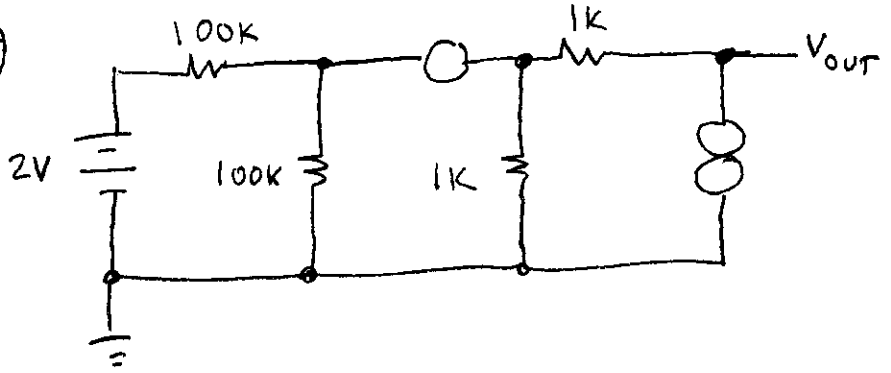
2)



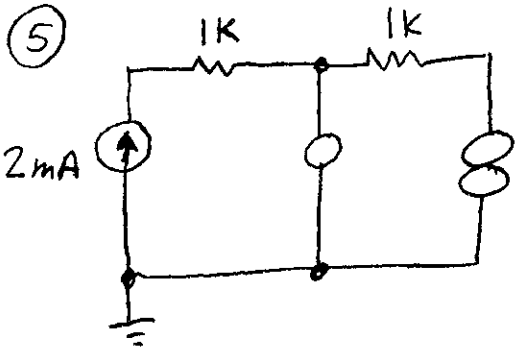
3)



4)



5)



6)