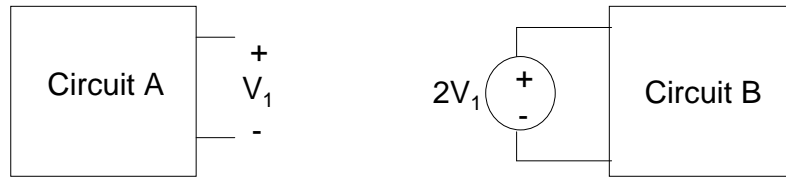## DEPENDENT VOLTAGE AND CURRENT SOURCES

A linear dependent source is a voltage or current source that depends linearly on some other circuit current or voltage.

Example: You watch a certain voltmeter $V_1$ and manually adjust a voltage source $V_s$ to be 2 times this value. This constitutes a voltage-dependent voltage source.



This is just a manual example, but we can create such dependent sources electronically.

We will create a new symbol for dependent sources.

## DEPENDENT VOLTAGE AND CURRENT SOURCES

We can have voltage or current sources depending on voltages or currents elsewhere in the circuit.

Here, the voltage V provided by the dependent source (right) is proportional to the voltage drop over Element X. The dependent source does not need to be attached to the Element X in any way.
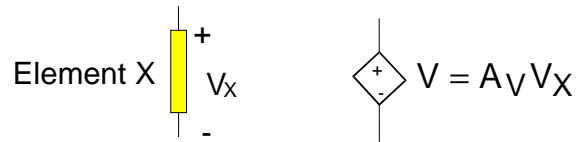


A diamond-shaped symbol is used for dependent sources, just as a reminder that it's a dependent source.

Circuit analysis is performed just as with independent sources.

## THE 4 BASIC LINEAR DEPENDENT SOURCES
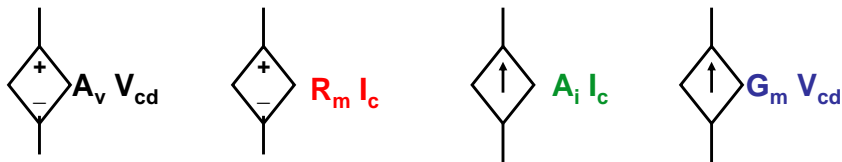
Constant of proportionality    Parameter being sensed

Output

**Voltage-controlled voltage source … $V = A_v V_{cd}$**

**Current-controlled voltage source … $V = R_m I_c$**

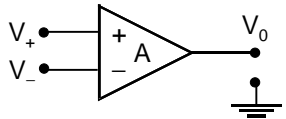**Current-controlled current source … $I = A_i I_c$**

**Voltage-controlled current source** … $I = G_m V_{cd}$

$A_v V_{cd}$    $R_m I_c$    $A_i I_c$    $G_m V_{cd}$

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## EXAMPLE OF THE USE OF DEPENDENT SOURCE
## IN THE MODEL FOR AN AMPLIFIER

AMPLIFIER SYMBOL          AMPLIFIER MODEL

Differential Amplifier    $V_0 = A(V_+ - V_-)$    Circuit Model in linear region

$V_+$

$V_-$    $A$    $V_0$
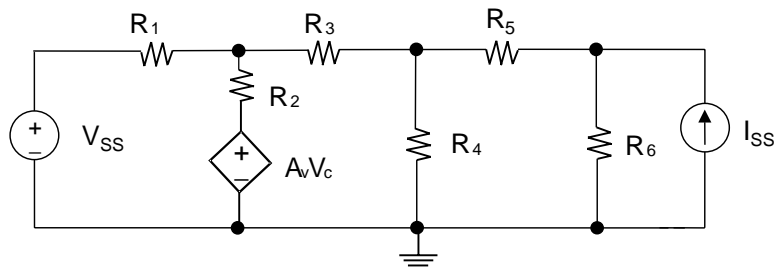
$R_i$ } $V_+ - V_-$    $A(V_+ - V_-)$    $V_0$
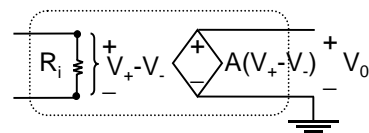
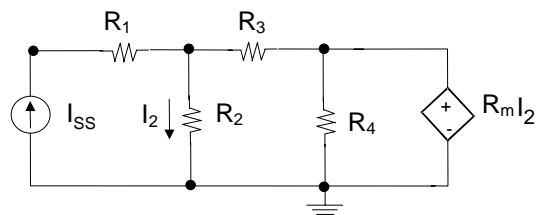$V_0$ depends only on input $(V_+ - V_-)$

This model when used correctly mimics the behavior of an amplifier but omits the complication of the many transistors and other components.

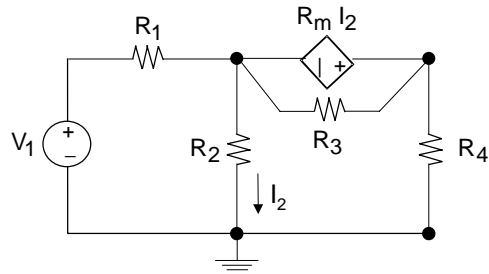We will learn more about the amplifier next week.

## NODAL ANALYSIS WITH DEPENDENT SOURCES

## NODAL ANALYSIS WITH DEPENDENT SOURCES

## ANOTHER EXAMPLE

## INTUITION

- A dependent source is like a "krazy resistor", except its voltage (current) depends on a different current (voltage).
- If the controlling voltage or current is zero, the dependent voltage source will have zero voltage (and the dependent current source will have zero current).
- There must be independent sources in the circuit for nonzero voltages or currents to happen!
- Math explanation: Node voltage analysis leads to

# $$Ax = b$$

The A matrix is nonsingular for real circuits, and is made of resistor values and dependent source parameters. The b vector is made of independent voltage & current source values. If b is zero and A is nonsingular, the solution must be zero!