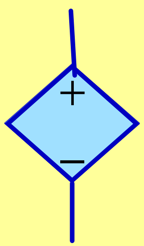
CIRCUITS WITH DEPENDENT SOURCES

A CONVENTION ABOUT DEPENDENT SOURCES.
UNLESS OTHERWISE SPECIFIED THE CURRENT AND VOLTAGE VARIABLES ARE ASSUMED IN SI UNITS OF *Amps* AND *Volts*



DEPENDENT VARIABLE

$V_D = \alpha I_X$

CONTROLLING VARIABLE

FOR THIS EXAMPLE THE MULTIPLIER MUST HAVE UNITS OF OHM

OTHER DEPENDENT SOURCES

$V_D = \beta V_X$ (β scalar)

$I_D = \gamma V_X$ (γ Siemens)

$I_D = \beta I_X$ (β scalar)

AN ALTERNATIVE DESCRIPTION

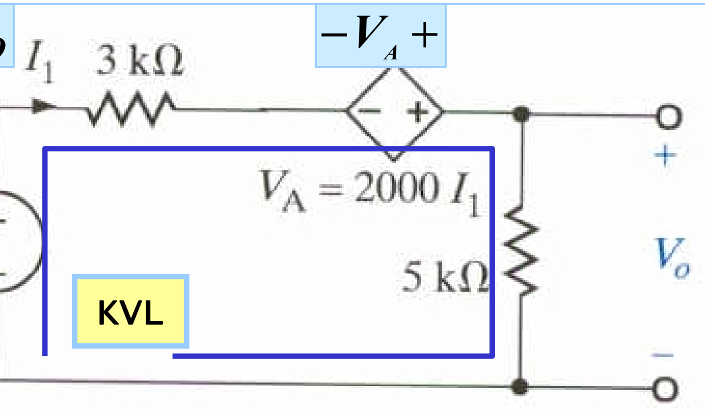
$V_D = \alpha I_X, \ \alpha = 2\left[\frac{V}{mA}\right]$

UNITS ARE EXPLICIT

ASSUMES CURRENT IN mA

GENERAL STRATEGY
TREAT DEPENDENT SOURCES AS REGULAR SOURCES AND ADD ONE MORE EQUATION FOR THE CONTROLLING VARIABLE

FIND V_O



A PLAN:
SINGLE LOOP CIRCUIT.
USE KVL TO DETERMINE CURRENT

$\text{KVL}: \ -12 + 3k * I_1 - V_A + 5k * I_1 = 0$

ONE EQUATION, TWO UNKNOWNS. CONTROLLING VARIABLE PROVIDES EXTRA EQUATION

$V_A = 2k * I_1$

REPLACE AND SOLVE FOR THE CURRENT

$I_1 = 2mA$

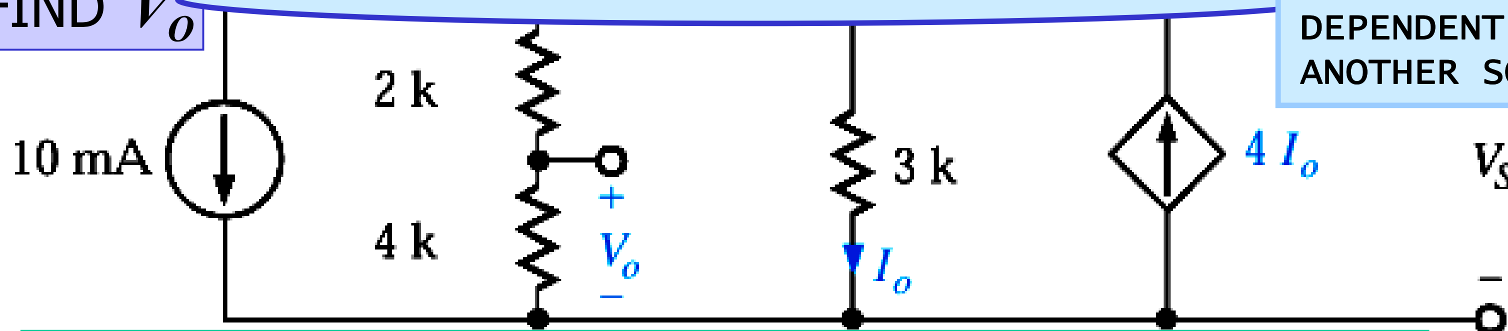
USE OHM'S LAW

$V_O = 5k * I_1 = 10V$

GEAUX

FIND V_O

KCL TO THIS NODE. THE DEPENDENT SOURCE IS JUST ANOTHER SOURCE



<u>A PLAN:</u>
IF V_s IS KNOWN V_0 CAN BE DETERMINED USING VOLTAGE DIVIDER.
TO FIND V_s WE HAVE A SINGLE NODE-PAIR CIRCUIT

$$10 \times 10^{-3} + \frac{V_S}{2k + 4k} + \frac{V_S}{3k} - 4I_o = 0$$

ALGEBRAICALLY, THERE ARE TWO UNKNOWNS AND JUST ONE EQUATION

THE EQUATION FOR THE CONTROLLING VARIABLE PROVIDES THE ADDITIONAL EQUATION

$$I_o = \frac{V_S}{3k}$$

SUBSTITUTION OF I_0 YIELDS

$$\frac{10}{1k} + \frac{V_S}{6k} + \frac{V_S}{3k} - \frac{4V_S}{3k} = 0$$

$$*/6k \Rightarrow 5V_S = 60$$

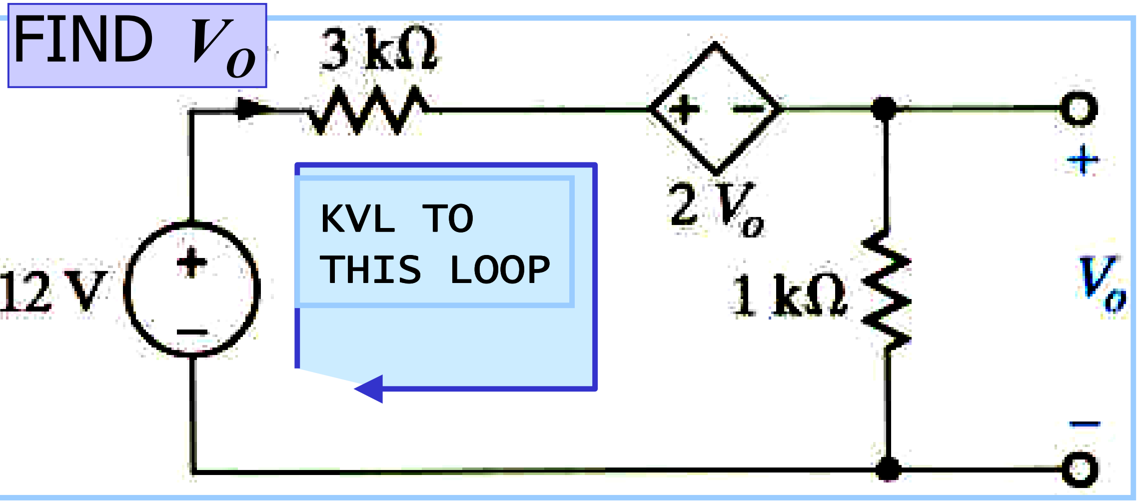
VOLTAGE DIVIDER

$$V_O = \frac{4k}{4k+2k} V_S = \frac{2}{3}(12)V$$

NOTICE THE CLEVER WAY OF WRITING mA TO HAVE VOLTS IN ALL NUMERATORS AND THE SAME UNITS IN DENOMINATOR

GEAUX

FIND V_o



A PLAN:
ONE LOOP PROBLEM.
FIND THE CURRENT
THEN USE OHM'S LAW.

THE DEPENDENT SOURCE IS ONE MORE VOLTAGE SOURCE

$$-12 + 3kI + 2V_o + 1kI = 0$$

THE EQUATION FOR THE CONTROLLING VARIABLE PROVIDES THE ADDITIONAL EQUATION

$$V_o = 1kI$$

REPLACE AND SOLVE FOR CURRENT I

$$I = 2\text{ mA}$$

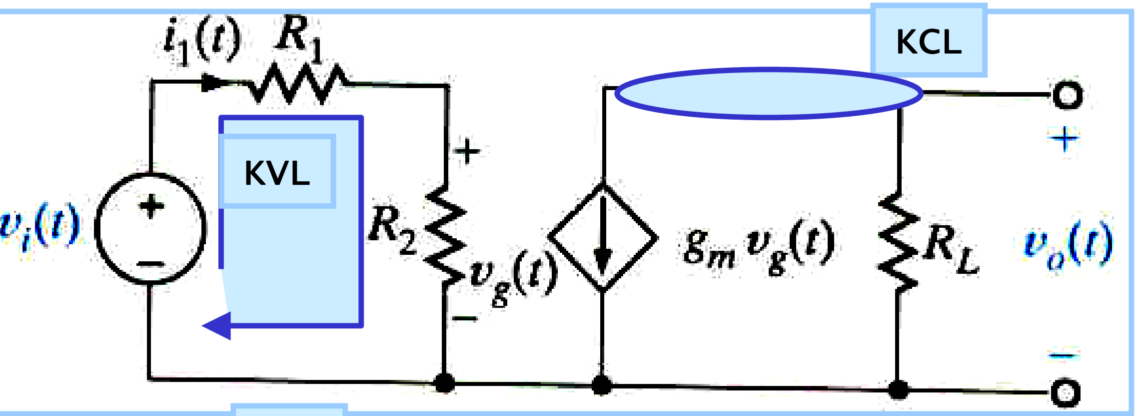
… AND FINALLY

$$V_o = 1kI$$
$$= 2\text{ V}$$

GEAUX

FIND $G = \frac{v_O(t)}{v_i(t)}$

A PLAN:
ONE LOOP ON THE LEFT - KVL
ONE NODE-PAIR ON RIGHT - KCL



KVL

$$v_i(t) = i_1(t)(R_1 + R_2)$$

$$v_g(t) = i_1(t)R_2$$

$$v_g(t) = \frac{R_2}{R_1 + R_2} v_i(t)$$

ALSO A VOLTAGE DIVIDER

KCL

$$g_m v_g(t) + \frac{v_O(t)}{R_L} = 0$$

$$v_o(t) = -g_m v_g(t) R_L$$

$$v_o(t) = \frac{-g_m R_L R_2}{R_1 + R_2} v_i(t)$$

$$\frac{v_o(t)}{v_i(t)} = -\frac{g_m R_L R_2}{R_1 + R_2}$$

STOP