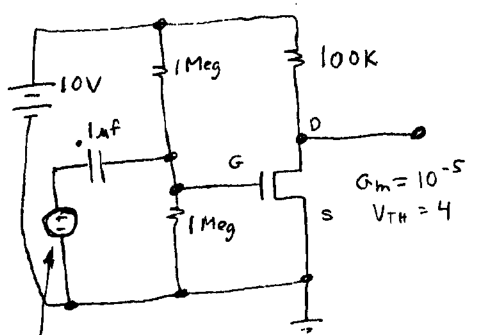
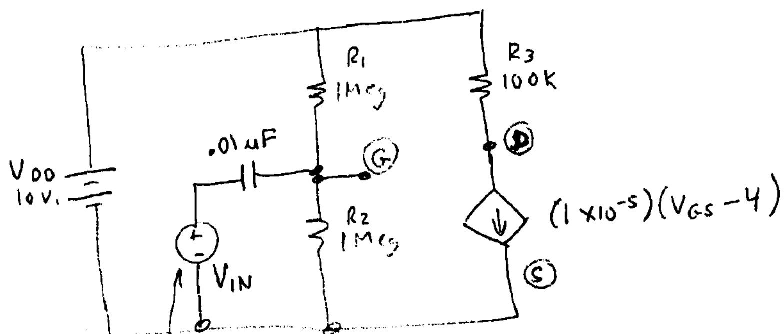
A sample circuit — using superposition --
AC and DC solution:

From a quiz ---



$.001 \cos(2\pi 1000 t)$
$.001 \cos(2\pi 10 t)$] either of these

Equivalent circuit:



$.001 \cos(2\pi f t)$

$f = \begin{cases} 1000 \text{ Hz} \\ 10 \text{ Hz} \end{cases}$

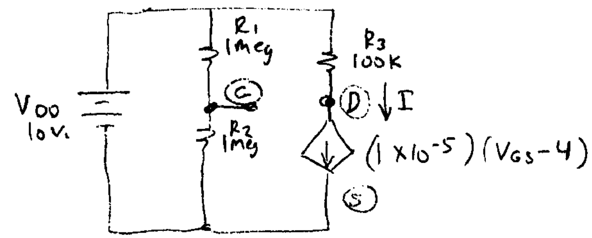
Call it ".001 ∠0"

What is V_D?

What is $\dfrac{V_D}{V_{IN}}$ 'AC component?

Idea: use superposition —

First set AC sources to zero — solve.



$$V_G = \left(\frac{R_2}{R_1+R_2}\right)V_{DD} = \frac{10^6}{10^6+10^6}10 = 5$$

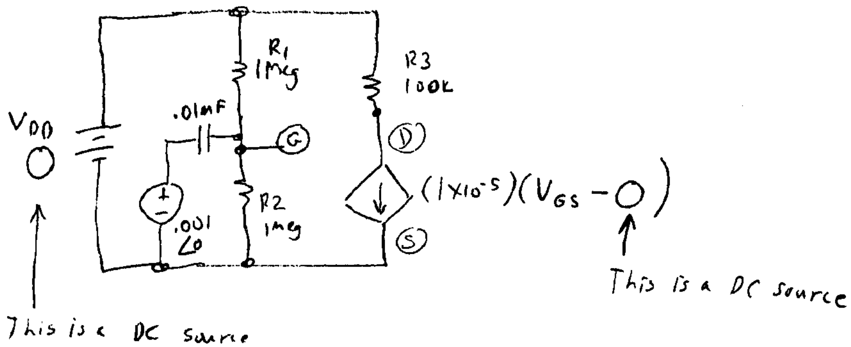
$$I = (10^{-5})(V_{GS}-4) = (10^{-5})(5-4) = 10^{-5}\text{ A.}$$

$$V_{R3} = IR = (10^{-5})(10^5) = 1$$

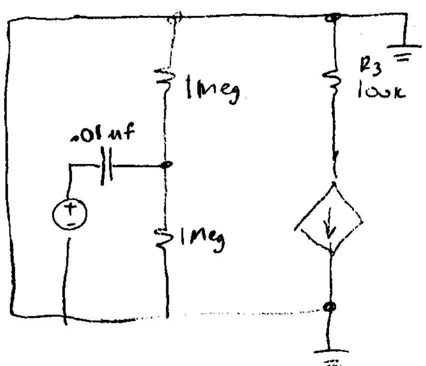
$$V_{DS} = V_{DD} - V_{R3} = 9.$$

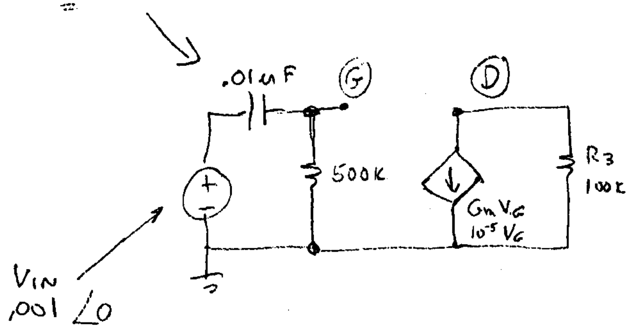
(repeat of a quiz from a few weeks ago)

Now, set the DC sources to zero, -- leaving only the AC sources --.



Leaving - - -





Node equations:

(G) $$\frac{V_G}{R} + \frac{V_G - V_{IN}}{\frac{1}{j\omega C}} = 0$$

Solve for $\frac{V_G}{V_{IN}}$

$$\frac{V_G}{R} + \frac{V_G}{\frac{1}{j\omega C}} - \frac{V_{IN}}{\frac{1}{j\omega C}} = 0$$

$$\frac{V_G}{R} + j\omega C V_G - j\omega C V_{IN} = 0$$

$$V_G\left(\frac{1}{R} + j\omega C\right) = V_{IN}(j\omega C)$$

$$\frac{V_G}{V_{IN}} = \frac{j\omega C}{\frac{1}{R} + j\omega C}$$

$$\frac{V_G}{V_{IN}} = \frac{j\omega CR}{1 + j\omega CR}$$

(D) $$G_m V_G + \frac{V_D}{R_3} = 0$$

solve for $\frac{V_D}{V_G}$

$$\frac{V_D}{R_3} = -G_m V_G$$

$$\frac{V_D}{V_G} = -G_m R_3$$

$$= -(10^{-5})(10^5)$$

$$\frac{V_D}{V_G} = -1$$

bad example -- this value is only by chance

combine - - -

$$\frac{V_D}{V_{IN}} = \frac{V_D}{V_G} \cdot \frac{V_G}{V_{IN}} = -\frac{j\omega CR}{1 + j\omega CR}$$

$\omega = 2\pi\, 1000$: $j\omega CR = j\omega(.01\times10^{-6})(5\times10^5)$ $= j5$

$$\frac{j5}{1+j5} = .961 + j.192 = .98 \angle .197 \text{ rad} = .98 \angle 11^\circ$$

$\omega = 2\pi\, 10$: $= j.05$

$$\frac{j.05}{1+j.05} = .0024938 + j.0498753 = .0499 \angle 1.52 \text{ rad} = .0499 \angle 87.138^\circ$$