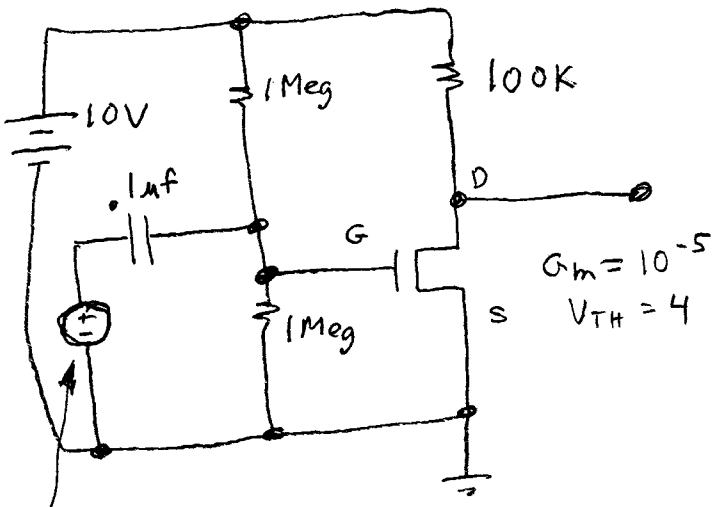
A sample circuit — using superposition --

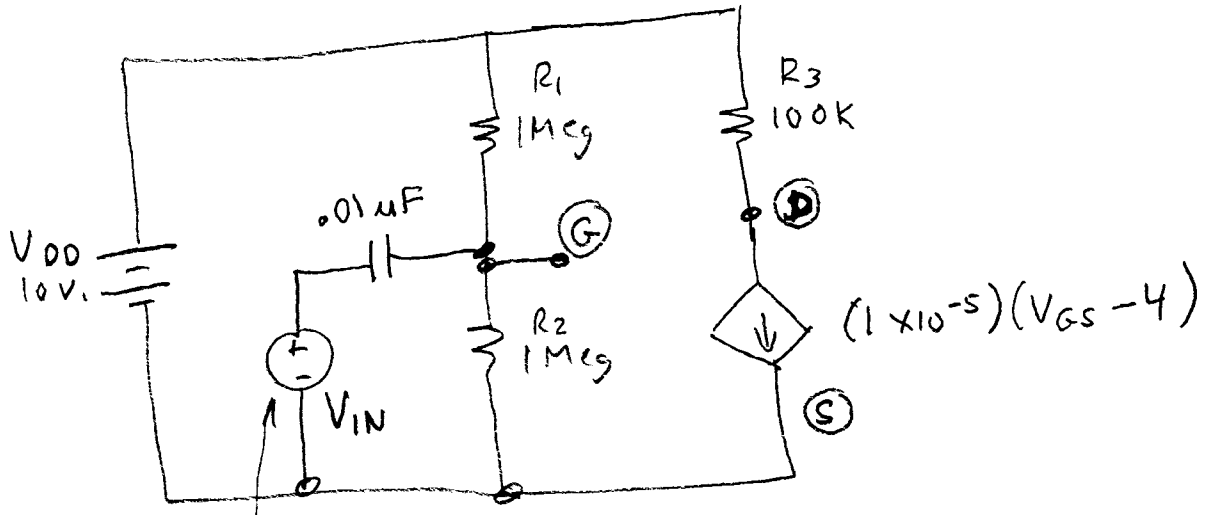
AC and DC solution:

From a quiz---



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

Equivalent circuit:



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

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

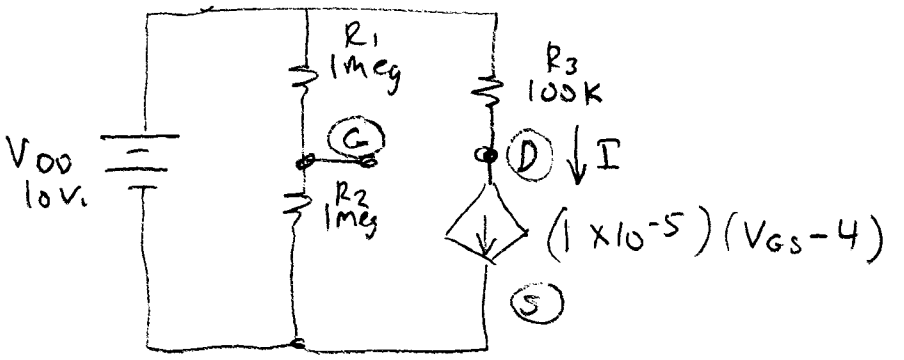
Call it ".001 ∠0"

What is V_D?

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

Idea: use superposition –

First set AC sources to zero – solve.



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

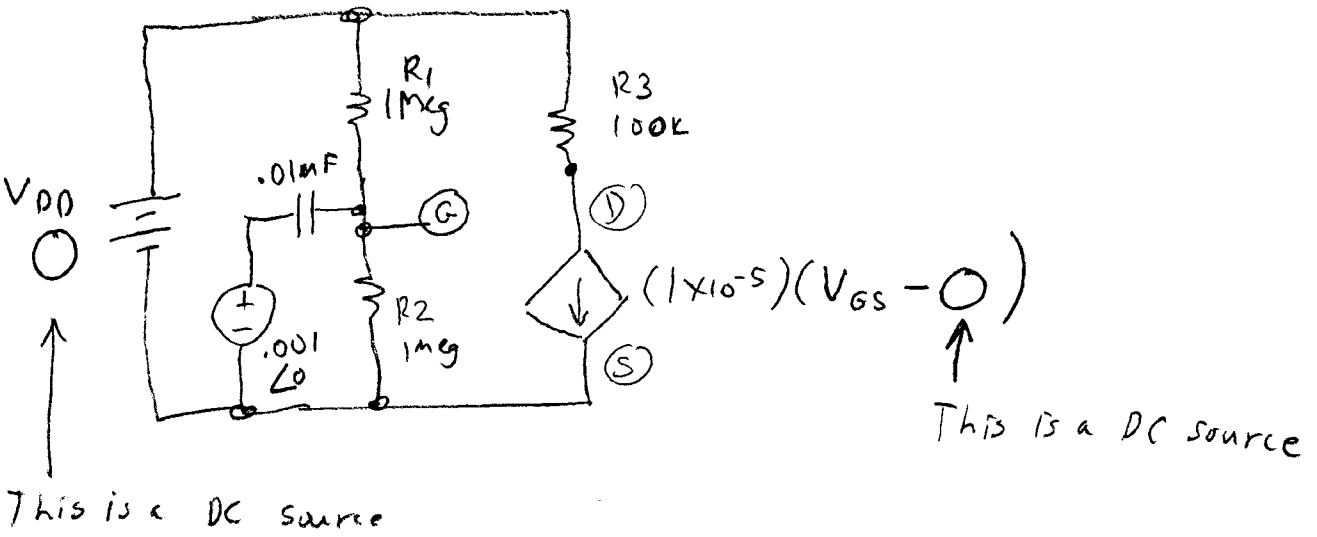
$$I = (10^{-5})(V_{GS}-4) = (10^{-5})(5-4) = 10^{-5}\ A.$$

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

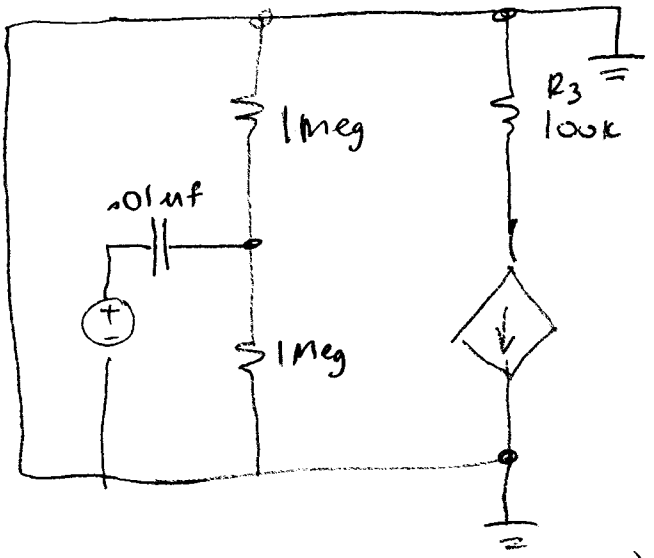
$$V_{DS} = V_{DD} - V_{R3} = 9.$$

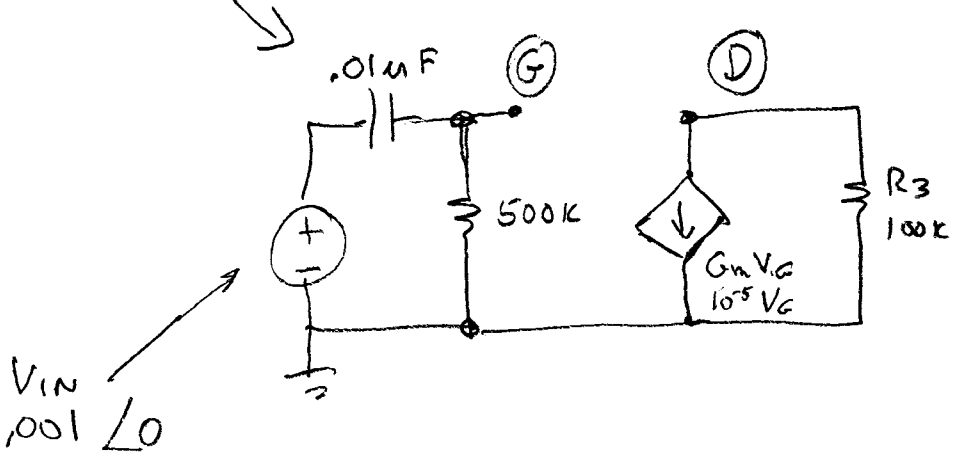
(repeat of a quiz from a few weeks ago)

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



Leaving---





Node equations:

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

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

$$\frac{V_G}{R} + \frac{V_G}{\frac{1}{jwC}} - \frac{V_{IN}}{\frac{1}{jwC}} = 0$$

$$\frac{V_G}{R} + jwC V_G - jwC V_{IN} = 0$$

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

$$\frac{V_G}{V_{IN}} = \frac{jwC}{\frac{1}{R} + jwC}$$

$$\frac{V_G}{V_{IN}} = \frac{jwCR}{1 + jwCR}$$

(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 ...

$$\frac{V_D}{V_{IN}} = \frac{V_D}{V_G} \cdot \frac{V_G}{V_{IN}} = -\frac{jwCR}{1+jwCR}$$

$\omega = 2\pi 1000$:

$$jwCR = jw(.01 \times 10^{-6})(5 \times 10^5)$$

$$= j5$$

$$\frac{j5}{1+j5} = .961 + j.192$$

$$= .98 \angle .197 \text{ rad}$$

$$= .98 \angle 11^\circ$$

$\omega = 2\pi 10$:

$$= j.05$$

$$\frac{j.05}{1+j.05} = .0024938 + j.0498753$$

$$= .0499 \angle 1.52 \text{ rad}$$

$$= .0499 \angle 87.138^\circ$$