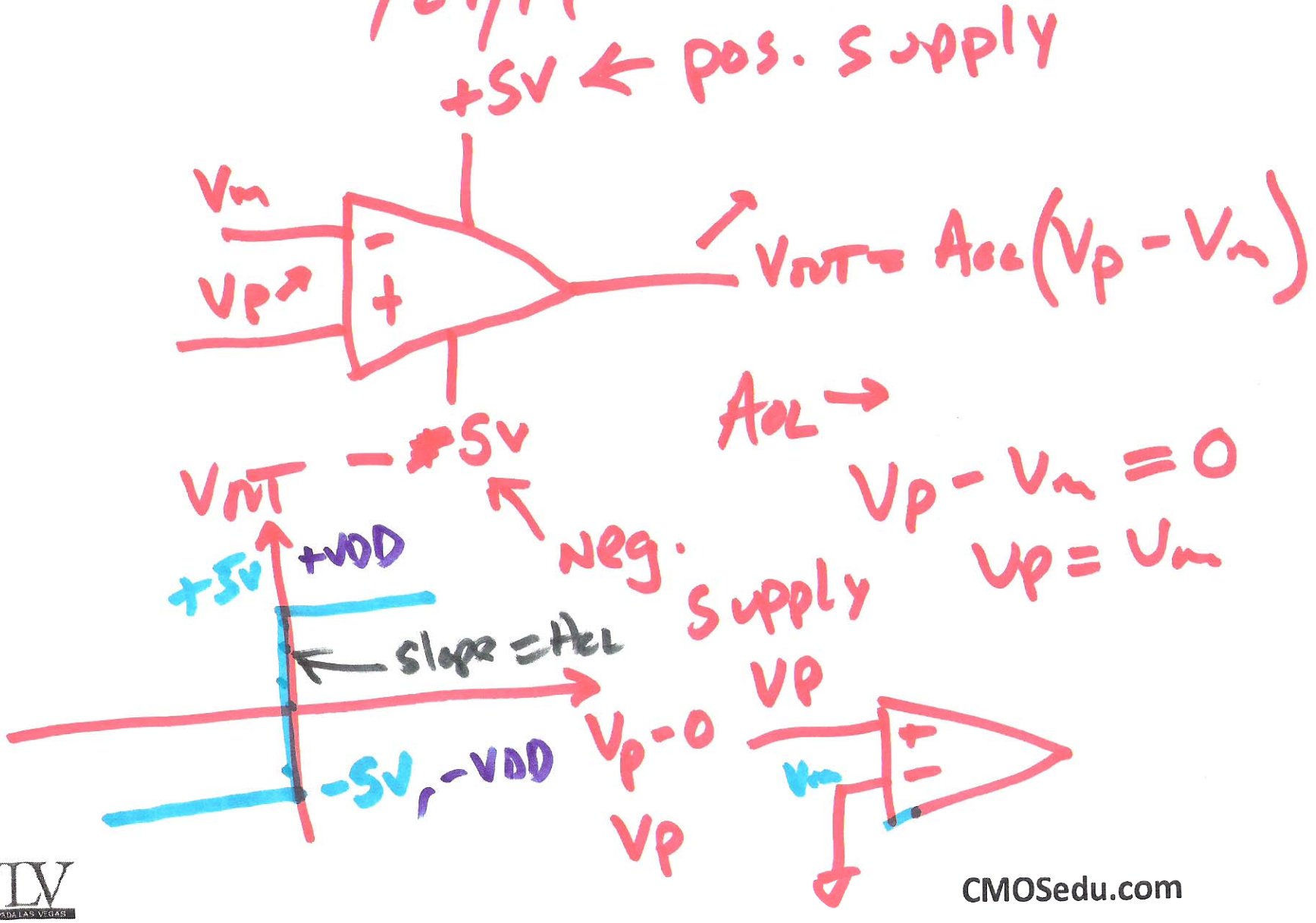
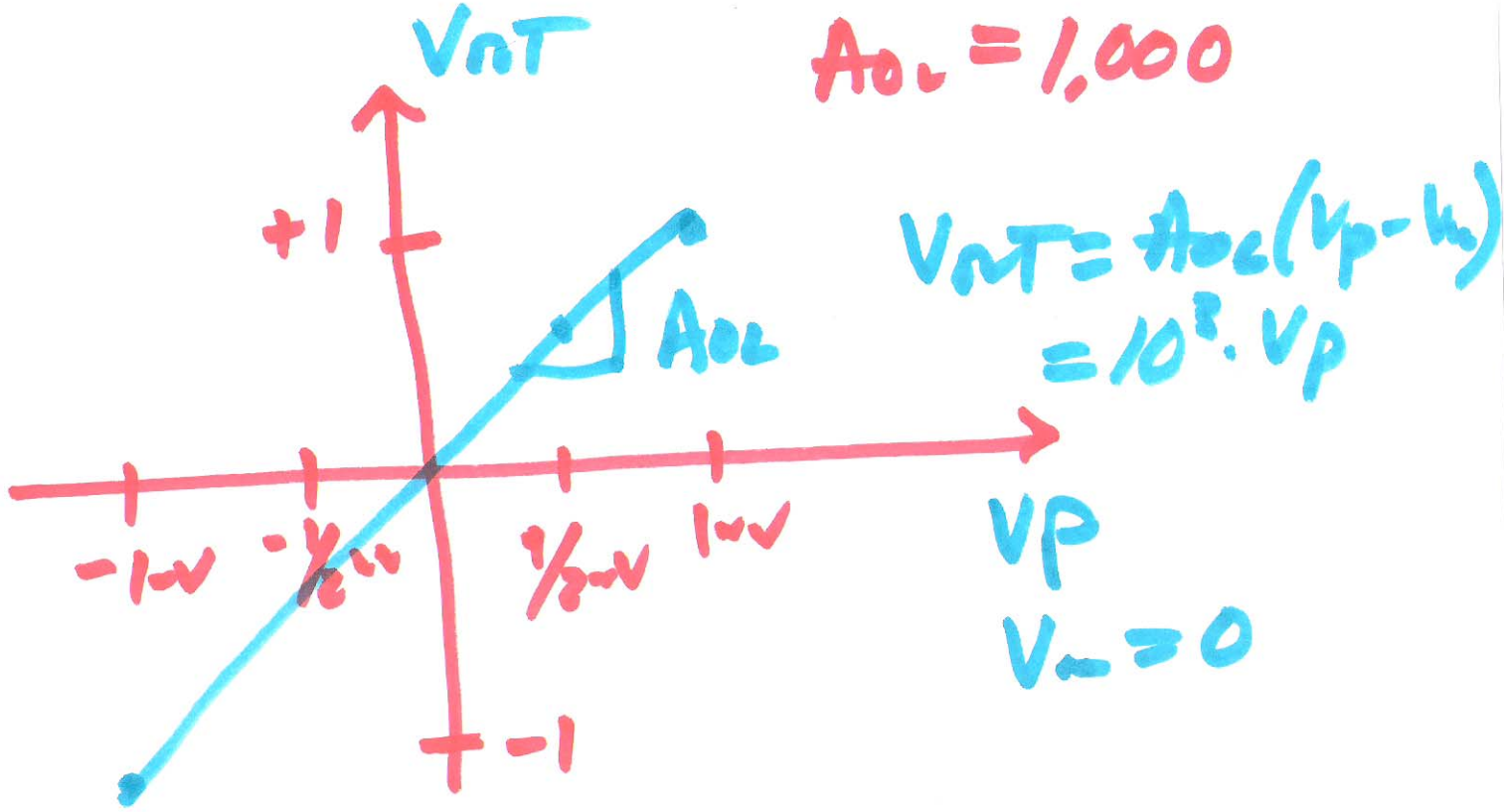
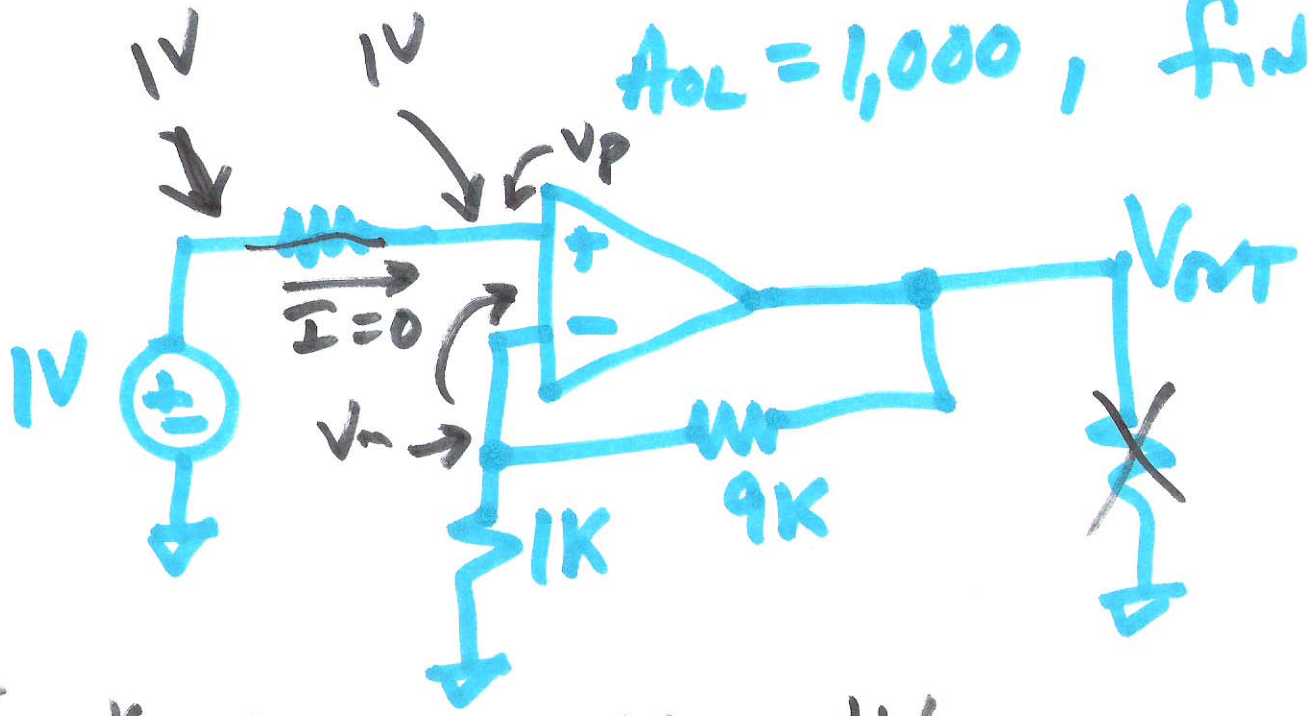
EE320 Lecture 3

1/29/14 EE 320




VOUT
+1
-1
AOL
-1mV
-½mV
½mV
1mV
VP
VOUT = AOL(VP - VN)
= 10³ · VP
AOL = 1,000
VN = 0



ideal

NON-INVERTING

$$\frac{V_{OUT}}{V_{IN}} = 1 + \frac{9K}{1K}$$

$$= \frac{1K+9K}{1K}$$

$$= +10V$$

ideal

Plot V_{OUT} vs. $(V_P - V_m)$

$V_P = 1V$

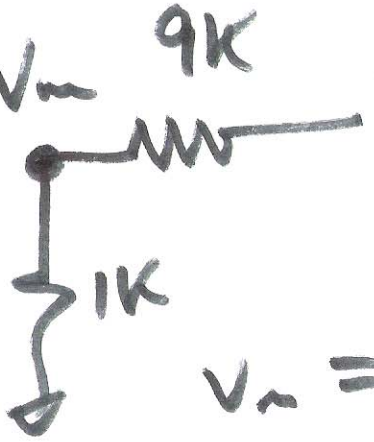
$$V_m = \frac{V_{OUT}}{10}$$

$$V_{OUT} = A_{OL}(V_P - V_m)$$

$$V_{OUT} = 10^3\left(1 - \frac{V_{OUT}}{10}\right)$$

$$V_{OUT}(1 + 100) =$$

1000



$$V_m = V_{OUT} \cdot \frac{1K}{1K+9K}$$

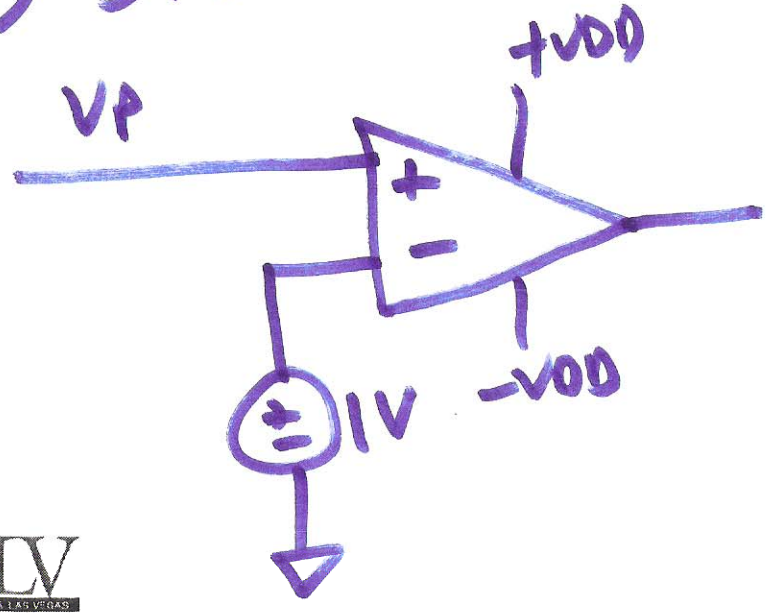
$$V_{OUT} = \frac{1000}{101} = 9.99$$

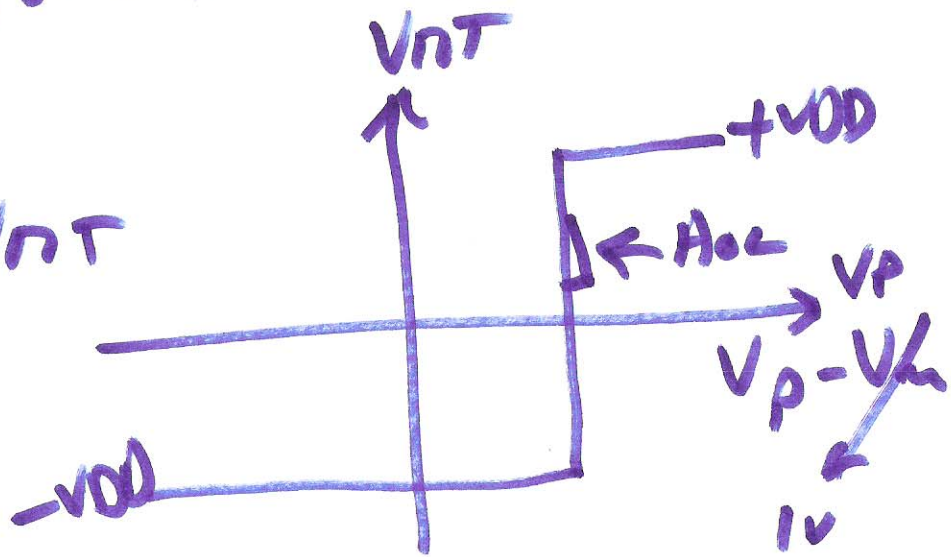
actual

Suppose an op-amp has an open-loop gain of 2,000. if $V_M = 1V$ sketch V_{OUT} vs. V_P with no feedback, that is, open loop.

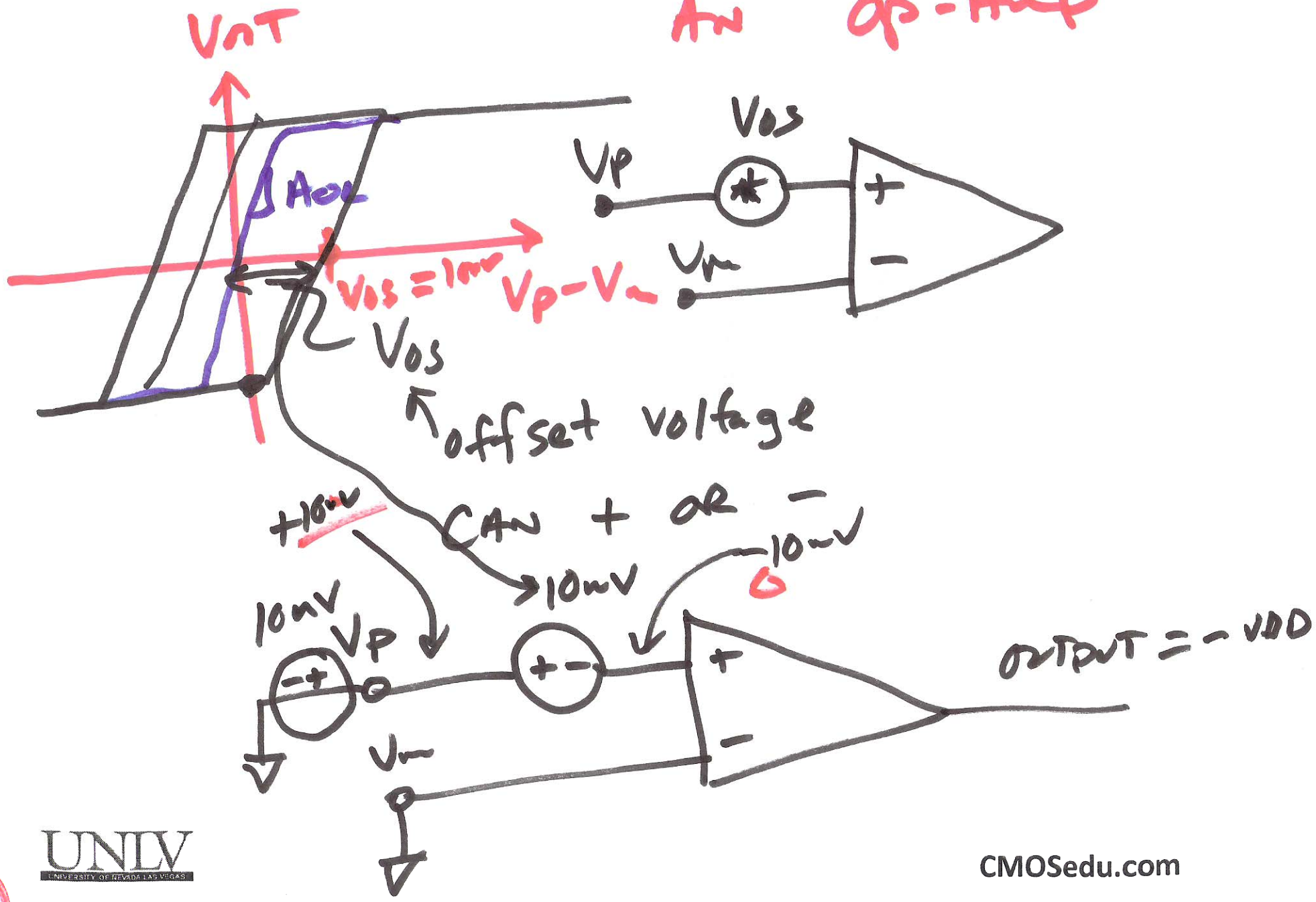
a) What is A_{OL}? $A_{OL} = 2k$

b) Sketch the circuit showing the op-amp.





Offset Voltage of An op-Amp



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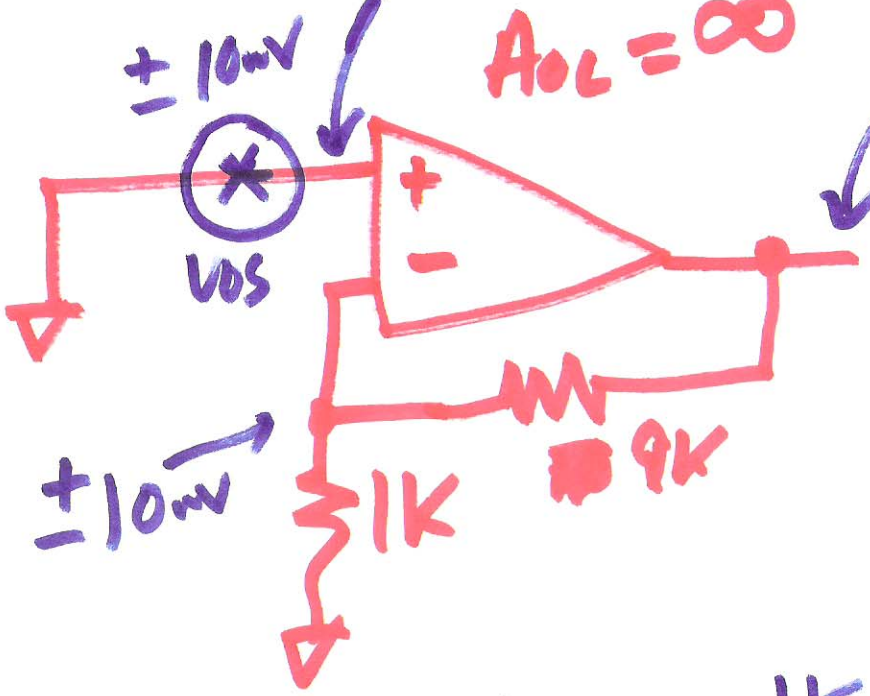
$V_{OS} = \pm 10mV$, find V_{OUT}



$A_{OL} = \infty$

$\pm 100mV$

$V_{OUT} = A_{OL}(V_p - V_n)$

$A_{CL} = \frac{V_{OUT}}{V_p} = 10$

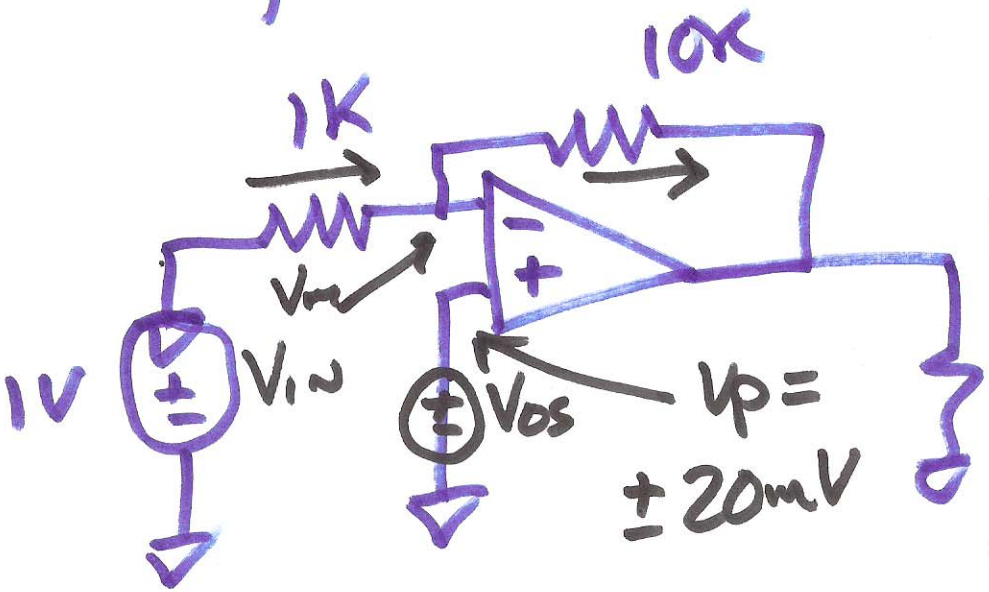
$V_{OUT} \cdot \frac{1K}{1K+9K} \left(\frac{1}{10}\right) = \pm 10mV$

$V_{OUT} = \underline{\underline{\pm 100mV}}$

6)

$A_{OL} = 500$, $V_{os} = \pm 20mV$

find V_{oT}



inverting op-amp

$A_{CL}|_{ideal} = \frac{V_{oT}}{V_{in}}$

$V_{oT} = 500(V_p - V_m) = -\frac{R_2}{R_1} = -\frac{10V}{V}$

$V_{oT}|_{ideal} = -10V$

$$\frac{1 - V_m}{1K} = \frac{V_m - V_{oT}}{10K}$$

$$V_{oT} = 500(\pm 20mV - V_m)$$

$$V_{oT} = \pm 10 - 500V_m$$

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7)

$$1 - V_m = \frac{V_n}{10} - \frac{V_{OUT}}{10}$$

$$10 - 10V_m = V_m - V_{OUT}$$

$$10 + V_{OUT} = 11V_m$$

$$10 \pm 10 - 500V_m = 11V_m$$

$V_m = 0 \Rightarrow V_{OS} = \pm 20mV$

$$\pm 20 = 511 V_m$$

$V_m = .0391 = 39mV$

$V_{OS} = +20mV$

$V_{OUT} = 500(V_p - V_m)$

$= 500(-20mV - 0)$

$= -10V$

$V_{OUT} = 500(20mV - 39mV)$

$= 500 \cdot (-19mV)$

$= -9.5V$

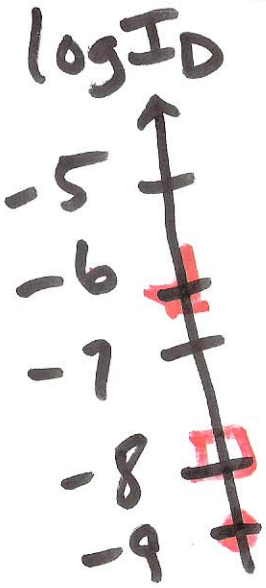
6dB ÷ 2 × 26dB ×20

I_D
1NA $= 10^{-9}$ A •
10NA $= 10^{-8}$ □
1μA $= 10^{-6}$ A ★

$20\log 10^{-9} = -180$

$20\log 10^{-8} = -160$

Octave ÷ 2 × 6dB/oct = 20dB/dec



-120dB

14dB ÷ 5

1 decade below 9 mHz 900KHz

-160 → 20dB (×10 +20dB, ÷10 -20dB) → -180

40dB ÷100

60dB ÷1000

1 decade ×10 up, ÷10 down

1 decade above 1.2KHz → 11.2KHz

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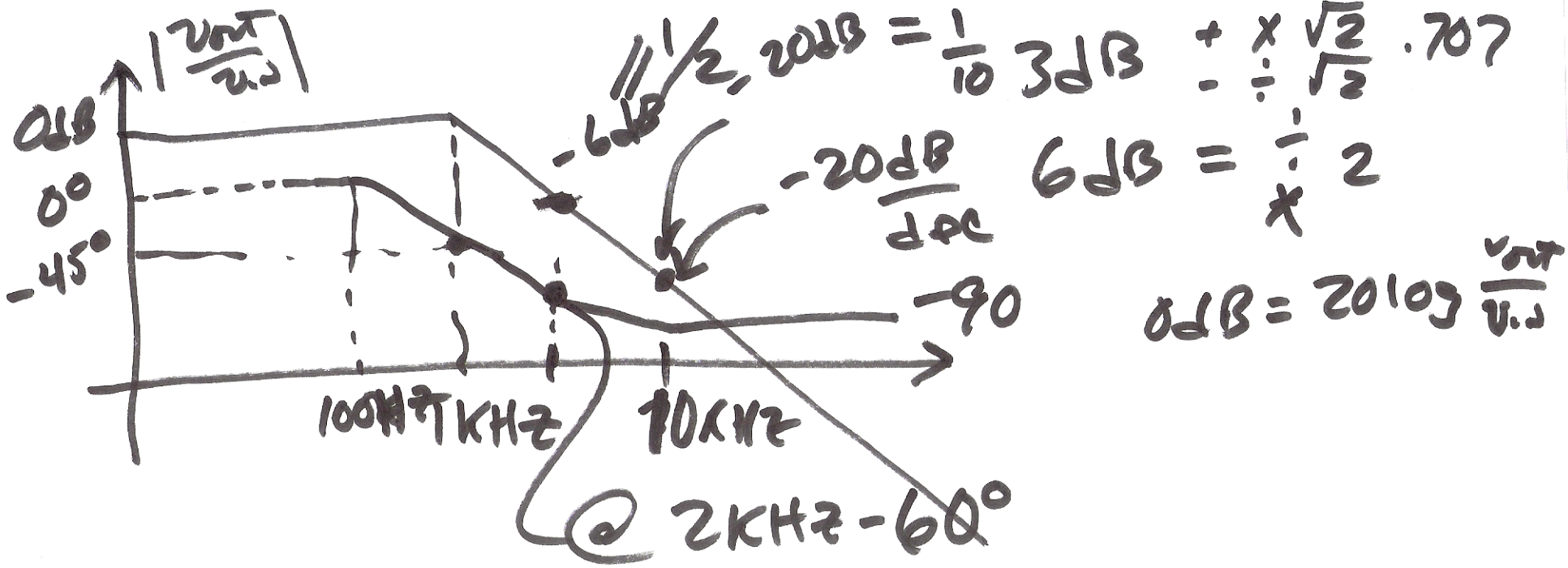

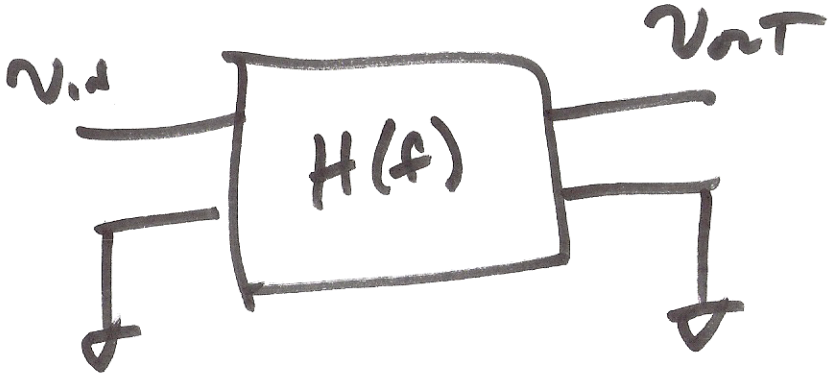

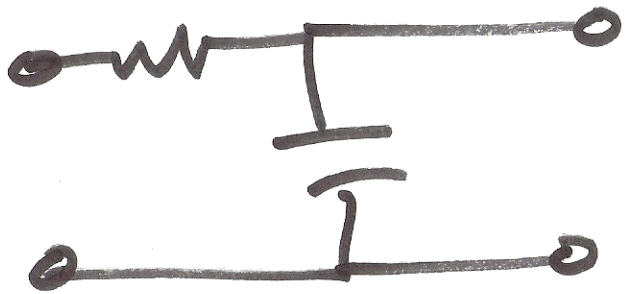

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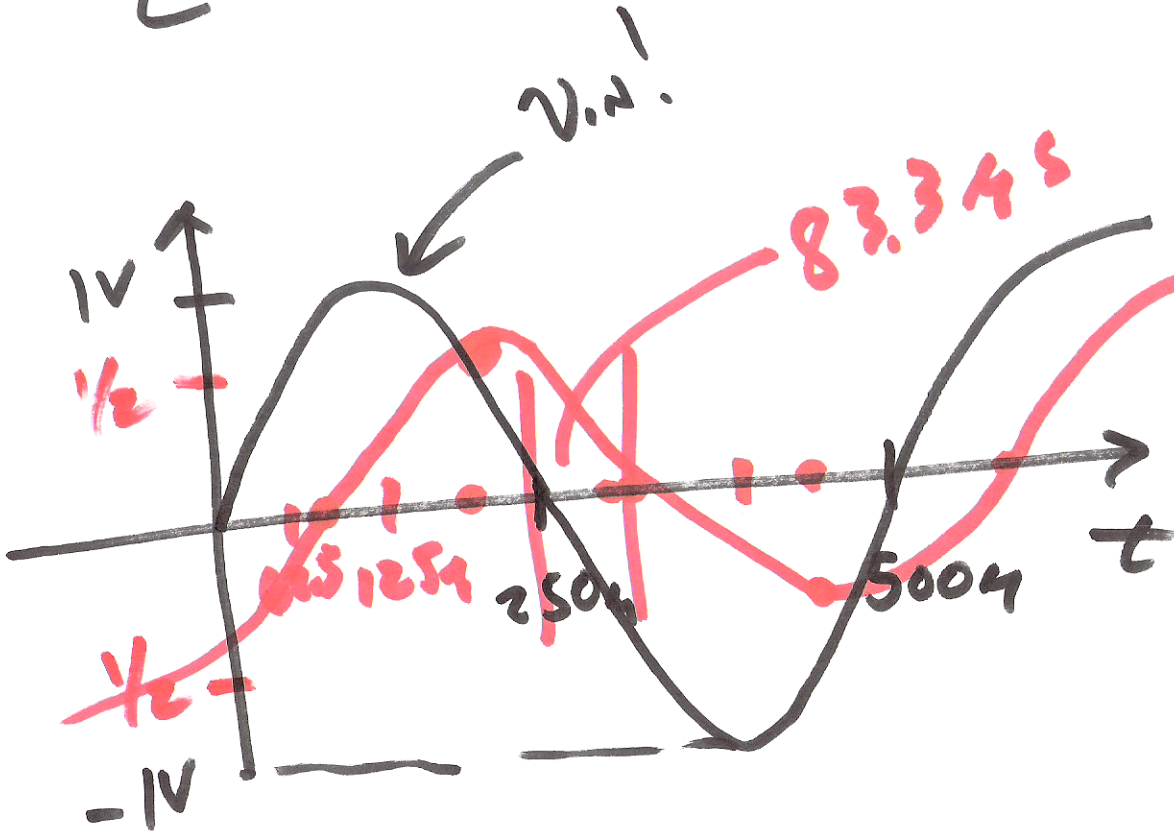
$\left|\frac{v_{out}}{v_{in}}\right| = -6\,dB = \frac{1}{2}$ @ 2KHz

$\angle\frac{v_{out}}{v_{in}} = -60°$

$v_{in} = 1\angle 0$

Sketch v_{out}

$\frac{1}{2} \cdot \frac{1}{10^3}$



$\theta = 360\,\frac{t_d}{T}$

$\frac{60}{360} \cdot 500\mu = t_d$

$t_d = 83.3\,\mu s$

$T = 500\mu$