Name: _____

EXAM #2

*Closed book, closed notes. Calculators may be used for numeric computations only. All work is to be your own - **show your work** for maximum partial credit.*

Data:

Use the following data in all the problems in the Exam:

V_{DD}	1.8V
$\mu_n C_{ox}$	200 μA/V^2
$\mu_p C_{ox}$	100 μA/V^2
V_{THN}	0.4V
$\lvert V_{THP}\rvert$	0.4V

NMOS Equations

Cutoff region

$I_D = 0, V_{GS} < V_{THN}$

Triode (linear) region

$$I_D = \mu_n C_{ox} \frac{W}{L}\left((V_{GS} - V_{THN}) V_{DS} - \frac{V^2_{DS}}{2} \right), V_{GS} > V_{THN}, V_{DS} < V_{GS} - V_{THN}$$

Saturation region

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{THN})^2 (1 + \lambda V_{DS}), V_{GS} > V_{THN}, V_{DS} \geq V_{GS} - V_{THN}$$

Small-signal Parameters

$$g_m = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{THN}) = \sqrt{2 \mu_n C_{ox} \frac{W}{L} I_D} = \frac{2 I_D}{V_{GS} - V_{THN}}$$

$$r_0 = \frac{1}{\lambda I_D}$$

PMOS Equations

Assuming all positive convention, make the substitutions in the above equations: $\mu_n \rightarrow \mu_p$, $V_{GS} \rightarrow V_{SG}$, $V_{DS} \rightarrow V_{SD}$, and $V_{THN} \rightarrow |V_{THP}|$

Rectifier Equations

$$V_R = \frac{1}{2}\left(\frac{V_p - 2V_{D,on}}{R_L} \right) \frac{1}{C_1 f_{in}} = \frac{I_L}{2 C_1 f_{in}}$$

$$I_p \approx \frac{V_p}{2R_L}\left(R_L C_1 \omega_{in} \sqrt{\frac{2V_R}{V_p}} + 1 \right)$$

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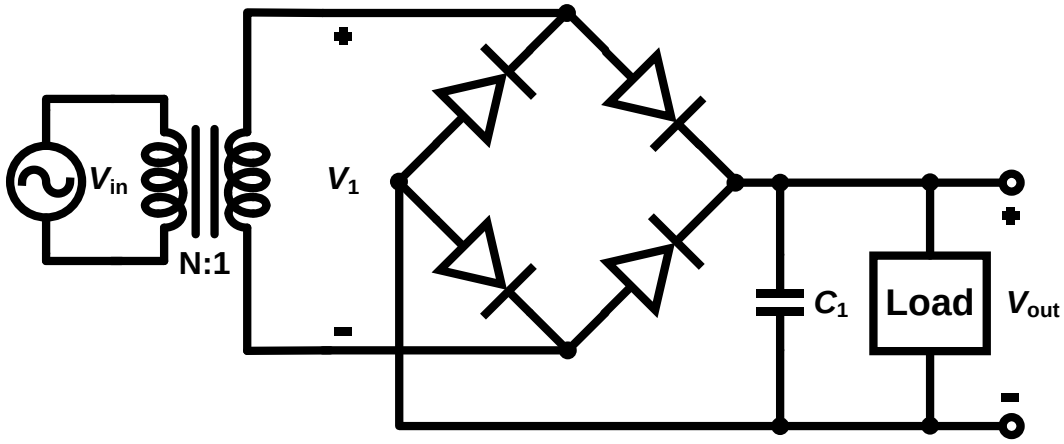
1. (30 points) Consider the rectifier circuit shown below. The input source is the 110 V_{rms}, 60 Hz AC line voltage. The on-voltage of the diodes is $V_{D,on}$ = 0.8V. The rectifier is expected to deliver an average power of 3W to a cellphone with a DC voltage of 3.3V and a ripple of 0.3V.



(a) (5 points) What is the peak voltage at V_1 required at the input of the diode bridge?

(b) (5 points) Find the turn ratio of the step-down transformer to achieve V_1 calculated in part (a)?

(c) (5 points) On the diagram, trace out the complete current paths for positive and negative input half-cycles.

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(d) (5 points) Calculate the value of the smoothing capacitor (C_1) in μF units to meet the ripple specification of 300mV.

(e) (5 points) What is the minimum peak inverse voltage (PIV) (i.e. the maximum reverse bias voltage) the diodes should withstand?

(f) (5 points) Plot the **properly labeled** waveforms at V_1 and V_{out}.

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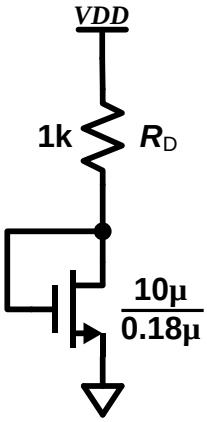
2. (20 points) In the circuit given below, W/L = 10µm/0.18µm, and V_{DD}=1.8V. Calculate the drain current of the NMOS. Assume λ=0.



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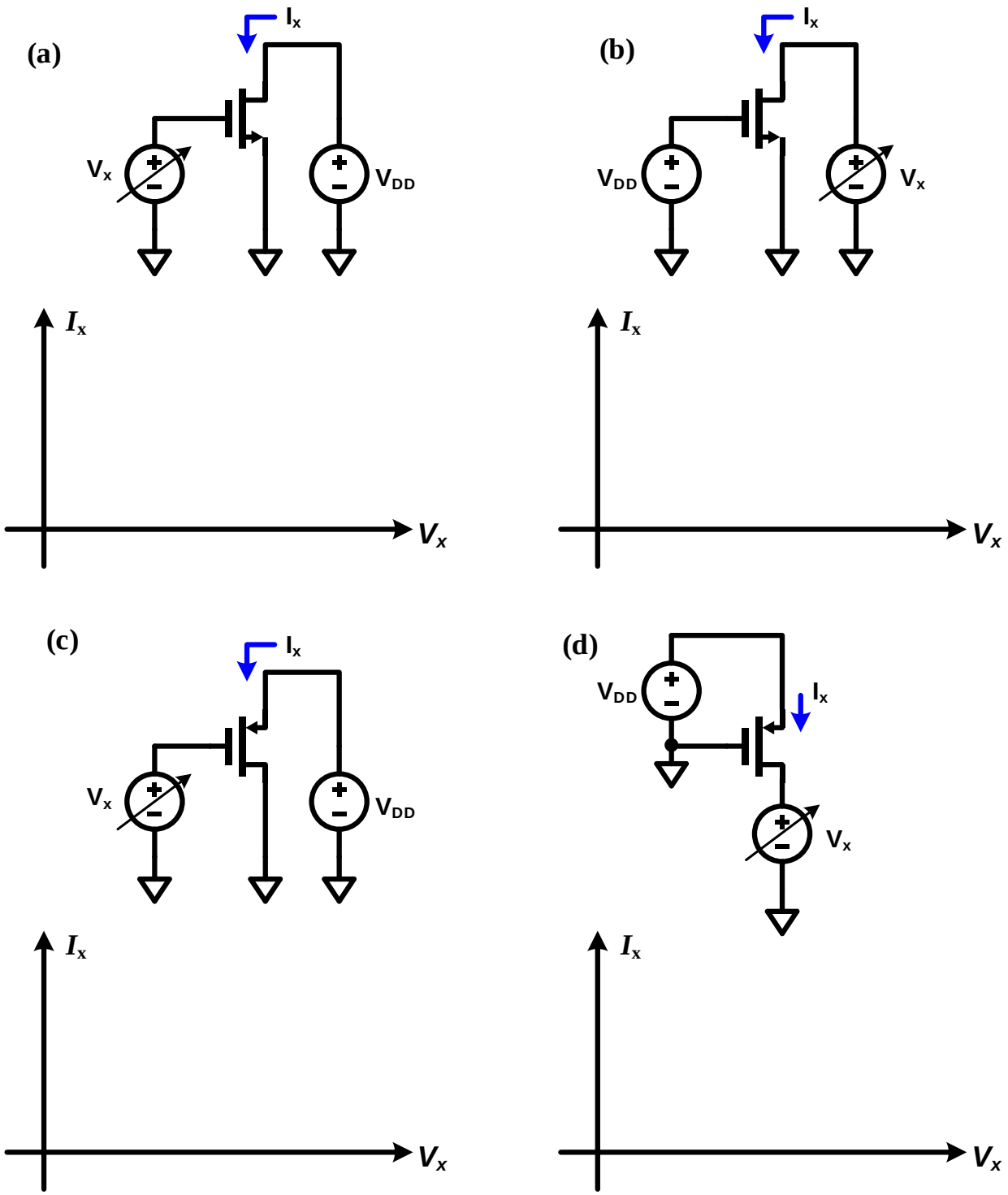
3. (20 points) For the circuits seen below, plot the current I_x as the voltage V_x is swept from 0 to V_{DD}.



4. (30 points) An NMOS with $\lambda=0.1\ V^{-1}$ must provide a small-signal gain, $\mathbf{g_m r_o = 25}$, for $V_{DS}=1.5V$. Determine the required value of W/L for $I_D=0.5mA$.