

## Exam 2 Review

### Exam Format (same as Exam 1)

~10 True/False: covering concepts and theory

~10 Multiple Choice: covering concepts and theory from lecture notes

Matching, fill in the blank, etc. type questions are possible substitutes for the above

~5 Problems: calculation problems that combine concepts learned in homework and class to test your overall understanding of the material

### Honor Pledge

You will be required to sign an honor pledge stating that you did not cheat or witness any cheating. Your exam will not be graded unless the honor pledge is signed!

### Calculators

Calculators will probably be allowed at the exam. However, you can not store any information or equations in calculators. Simple function calculators are preferred.

### Exam Coverage

All lecture notes and all topics covered in lecture since Exam 1.

Lecture Notes Ch7, Ch 11, Ch 12, Ch 13, Advanced Digital (slides 1-25); Homeworks 5-9.

Textbook chapters 7, 8 (parts), 11, 12, 13.

The exam will not cover material exclusive to lab assignments.

### List of Topics

- stick diagrams
- the following for inverters, multi-input gates, and transmission gates
  - voltage transfer characteristics & gate switching threshold (midpoint voltage)
  - transient response; rise and fall times; propagation delays
  - power consumption & activity coefficients
  - transistor sizing for performance; beta scaling
- multi-cell layout; signal & power routing
- digital functional blocks
  - buffers; multiplexers; decoders (active high/low); encoders
  - latches & flip flops, especially CMOS DFF; flip flop timing & transistor sizing
  - tri-states & C<sup>2</sup>MOS DFF
  - registers, shift/rotate, barrel shifters & counters (state machines not on exam)
- adders: half adder, full adder, ripple-carry adders
- carry look-ahead adders; Manchester carry generation (pass gate circuits)
- multiplier & ALU basics (Booth encoding not on exam)
- types of memory; volatility; static vs. dynamic
- SRAM cells, cell analysis & arrays; multi-port SRAM
- DRAM cells, cell analysis & arrays
- ROM/PROM/EPROM/EEPROM/PLA basic operation and structure
- pseudo-nMOS, dynamic/domino, differential, pass-gate logic structure
- STI, LDD, SOI, BiCMOS technologies

**Equations Sheet**

*The following equations will be provided for you on the exam. Only the following equations and constants will be provided and you will be responsible for knowing what each variable means and when to use each equation.*

$V = IR$	$Q = C V$ $I = Q / t$
$n p = n_i^2$	$\sigma = q(\mu_n n + \mu_p p)$
$R = L/\sigma A$	$J_x = \sigma E_x$
$C_{ox} = \epsilon_{ox}/t_{ox}$	$Q_c = -C_G(V_G - V_{tn})$
$k'_n = \mu_n C_{ox}, \beta_n = \mu_n C_{ox} (W/L)$	$R_n = 1 / \beta_n [(VDD - V_{tn})]$ , $R_p = 1 / \beta_p [(VDD -  V_{tp} )]$
$I_D = I_S (e^{V_D/V_T} - 1), \Psi_0 = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$	$W = \left[ \frac{2\epsilon(\Psi_0 + V_R) N_D + N_A}{q N_D N_A} \right]^{1/2}$
$C_j = A \left[ \frac{q\epsilon N_A N_D}{2(N_A + N_D)} \right]^{1/2} \left( \frac{1}{\sqrt{\Psi_0 + V_R}} \right)$	$W \cong x_p = \left[ \frac{2\epsilon(\Psi_0 + V_R)}{q N_A} \right]^{1/2}, W \cong x_n = \left[ \frac{2\epsilon(\Psi_0 + V_R)}{q N_D} \right]^{1/2}$
$C_{SB} = C_j A_{Sbot} + C_{jsw} P_{Ssw} C_{DB} = C_j A_{Dbot} + C_{jsw} P_{Dsw}$	$C_{GS} = 1/2 C_G C_{GD} = 1/2 C_G$
$t_f = 2.2 \tau_n, t_r = 2.2 \tau_p$ $t_p = 0.35(\tau_n + \tau_p)$	DRAM: $t_h = (C_s / I_L)(\Delta V_s) f_{refresh} = 1 / 2t_h$

region	nMOS equations	pMOS equations
Cutoff	$I_D = 0$	$I_D = 0$
Triode	$I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} [2(V_{GS} - V_m)V_{DS} - V_{DS}^2]$	$I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} [2(V_{SG} -  V_{tp} )V_{SD} - V_{SD}^2]$
Saturation (Active)	$I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{GS} - V_m)^2$	$I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{SG} -  V_{tp} )^2$

**Constants**

$kT = 0.026$  eV, at room temperature

$k = 8.62 \times 10^{-5}$  eV/K, Boltzmann's constant

$V_T = 0.026$  V, thermal voltage

$q = 1.6 \times 10^{-19}$  C (coulombs)

$n_i = 1.45 \times 10^{10}$  cm<sup>-3</sup>, Si at room temperature

$\epsilon_0 = 8.85 \times 10^{-14}$  F/cm

$\epsilon_{ox} = (3.9) 8.85 \times 10^{-14}$  F/cm

$\epsilon_{si} = (11.8) 8.85 \times 10^{-14}$  F/cm

**Quadratic Equation:**

$$ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

**DeMorgan's Rules**

$$(a * b)' = a' + b'$$

$$(a + b)' = a' * b'$$

**Useful Logic Properties**

$$1 + x = 1 \quad 0 + x = x$$

$$1 * x = x \quad 0 * x = 0$$

$$x + x' = 1 \quad x * x' = 0$$

$$a * a = a \quad a + a = a$$

$$ab + ac = a(b+c)$$

properties which can be proven

$$(a+b)(a+c) = a+bc \quad a + a'b = a + b$$

$$a + ab + ac = a$$