7. (a) Obtain the expression for noise margin high (NM$_H$) for a CMOS inverter from the voltage transfer characteristics.

(b) State how the Wilson MOS mirror can be modified to avoid the systematic current error. Derive an expression for output resistance in a Wilson MOS mirror.

7 + (2 + 3) = 12

Group – E

8 (a) Derive an expression for propagation delay in a CMOS inverter with capacitor load. Comment on the relation between propagation delay and capacitance of the load.

(b) Draw the CMOS realization to implement the following logic expression, $y = \overline{A(B + CD)}$

6 + 6 = 12

9 (a) Derive the expression for noise margin high from voltage transfer characteristics of a pseudo-NMOS inverter.

(b) Explain with detailed circuit diagram for a process of writing '0' in a 6T SRAM cell.

6 + 6 = 12

MICRO ELECTRONIC DEVICES AND CIRCUITS
(AEIE 5101)

**Time Allotted: 3 hrs**   **Full Marks: 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
__Any 5 (five)__ from Group B to E, taking __at least one__ from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1=10**

(i) The threshold voltage of an n-channel MOSFET can be increased by
(a) increasing the channel dopant concentration
(b) reducing the channel dopant concentration
(c) reducing gate oxide thickness
(d) reducing the channel length.

(ii) In a CMOS inverter the upper MOSFET is
(a) active load   (b) passive load
(c) complementary load   (d) none of the above.

(iii) What is the difference voltage output from an Op-Amp if the inputs are an ideal in-phase signal?
(a) The differential gain times twice the input signal
(b) The differential gain times the input signal
(c) The common-mode gain times twice the input signal
(d) The common-mode gain times the input signal.

(iv) The primary function of the bias circuit is to
(a) hold the circuit stable at V$_{CC}$
(b) hold the circuit stable at V$_{in}$
(c) ensure proper gain is achieved
(d) hold the circuit stable at the designed Q-point.

(v) What is the voltage gain of the unity follower?
(a) 0   (b) 1   (c) –1   (d) infinity.

(vi) A MOSFET is
(a) a current-controlled device
(b) a voltage-controlled device
(c) always forward-biased
(d) reversed biased.

(vii) Which components are hard to fabricate into ICs?
(a) diode
(b) resistor
(c) inductor
(d) transistor.

(viii) What is the most common method used for the growth of single crystals for IC fabrication?
(a) epitaxial growth
(b) czochralsky pulling technique
(c) film deposition
(d) photolithography.

(ix) Voltage follower is a special case of _____.
(a) inverting configuration
(b) non-inverting configuration
(c) difference configuration
(d) integrator configuration.

(x) The MOSFET below
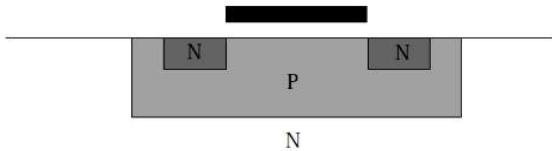
is labeled with the different types of silicon. The device is best described as
(a) an n-MOSFET in an N-well
(b) an n-MOSFET in a P-well
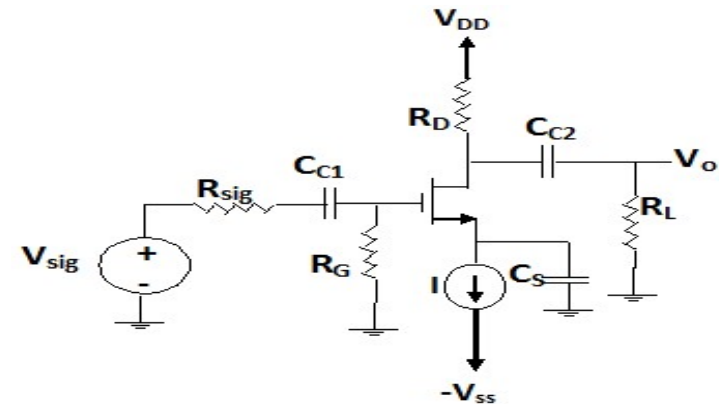(c) a p-MOSFET in an N-well
(d) a p-MOSFET in a P-well.

Group - B

2. (a) What are the various steps involved in IC fabrication process? Briefly describe each step.

   (b) Design an active resistor by using an n-channel MOSFET and derive the expression for resistance.

   $$5 + 7 = 12$$

3. (a) Derive the expression for current transfer ratio in a two transistor BJT Widlar current source.

   (b) For $I_{ref} = 1$ mA, find I_o when $V_o = 5V$. For a cascade MOS mirror utilizing devices with $V_t = 0.5V$, $\mu_n C_{ox} = 387 \mu A/V^2$, $V_a' = 5V/\mu m$, $W/L = 3.6 \mu m/0.36 \mu m$ and $I_{ref} = 100 \mu A$, find output resistance of the MOS mirror.

   $$6 + 6 = 12$$

Group - C

4. (a) An active-loaded MOS differential amplifier inside 741 Op-Amp has the fol specification: $(W/L)_n = 100$, $(W/L)_P = 200$, $\mu_n C_{ox} = 2\mu_p C_{ox} = 0.2$ $V_{An} = |V_{Ap}| = 20$ V, $I = 0.8$ mA, $R_{SS} = 25$ kΩ. Calculate G_M, Ad, $|A_{CM}|$ and CMRF MOS differential pair.

   (b) Deduce the expression for the transconductance for the input st a 741 Op-Amp.

   $$7 + 5$$

5. (a) Derive the expression for output resistance in a 741 Op-Amp fro small signal model of the output stage.

   (b) Derive the relationship between unity-gain bandwidth (f_t) and rate (SR) in case of a 741 Op-Amp.

   $$9 + 3$$

Group – D

6. (a) Derive the expression for CMRR of an active loaded MOS differ pair.

   (b) Perform small signal analysis on the given NMOS amplifier c shown in following figure. Find an expression for output impe and voltage gain.

$$8 + 4$$